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The Denver Wildlife Research Center

Highlights Report, 1991–92

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Issued August 1993

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Introduction

The past 2 years have been exciting and dynamic ones at the Denver Wildlife Research Center (DWRC). Following a reorganization within the Animal and Plant Health Inspection Service (APHIS), the Science and Technology division was dissolved and the Center was transferred back to APHIS' Animal Damage Control program.

The Center continues to make advances in the field of vertebrate pest management in a number of areas. Reregistration and registration of pesticides important to the operational program in animal damage control continues to be a high priority. DWRC scientists developed new techniques to control bird damage to fruit and row crops. Work continues on resolving the problems birds pose to aircraft. The Center expanded its research to reduce and eliminate bird damage to fruit and row crops. The search for nonlethal control methods and repellants received high priority, including new research in the area of immunocontraception for controlling the population of problem animals.

DWRC continued to strengthen its cooperative ties between universities and the public sector to offer a cost-effective way to explore the latest scientific breakthroughs and assess their possible applications to vertebrate pest management. Staff members gave presentations and tours of the facilities to many visitors.

In 1992, the Denver Wildlife Research Center continued to meet its commitments to the needs of its users and position itself to meet their needs even more effectively in the future.

Agricultural Crops

Repelling Birds From Dendrobium Orchids—A unique agricultural crop grown on the Hawaiian islands, dendrobium orchids are severely damaged each year by birds, specifically red-vented bulbuls. One method to protect orchids from bird damage is the application of a nonlethal chemical repellant. Center researchers cooperated with the Hawaii Governor's Agriculture Coordinating Committee, Hawaii Farm Bureau Federation, and Hawaii Animal Damage Control to test three candidate compounds, methiocarb (Mesurol™), ziram, and methyl anthranilate, in cage and field trials.

In cage experiments, red-vented bulbuls in control groups ate more untreated bird mash than birds presented with bird mash treated with mesurol, ziram, or methyl anthranilate. Of the three repellants, ziram and mesurol significantly reduced food consumption. In field trials, ziram and mesurol reduced bird damage to flowers by about 80 percent.

Overall, the present findings suggest that any one of these chemical pesticides may be utilized as a bird repellant on flowering plants. Center researchers feel that field-test application rates of ziram and mesurol were probably higher than needed for effective control. Therefore, further testing of these chemicals should be undertaken at lower application rates.

Repelling Snow Geese From Cover Crops—Snow geese overwinter in New Jersey and other mid-Atlantic States, and migrant populations are increasing rapidly. As a result, snow geese now cause problems for farmers and wildlife managers alike. Unlike Canada geese, whose depredations occur primarily in the fall, snow geese do most of their damage in late February and early March as the birds graze in anticipation of spring migration. Rye, winter wheat, and turf are damaged, reducing nitrogen fixation and exposing fields to wind erosion. Because geese are implicated as a primary vector in the transmission of agriculturally important pathogens and parasites, even farmers without substantial goose damage to crops express concerns over visits by flocks to their fields.

Recent cooperative work by scientists from DWRC and Monell Chemical Senses Corporation shows that white plastic flags, at a density of 1 flag/acre, effectively repel snow geese for 6–8 weeks at a low cost ($0.80/unit). Comparably effective mylar flagging costs 50 percent more.

We speculate that white flagging may be a useful snow-goose damage-control tool in locations other than agricultural fields. For example, flagging might encourage snow-goose dispersal in marshes where excessive grazing has had substantial negative impacts. The DWRC–Monell team plans to test this possibility, as well as a comparative evaluation of white flags, black flags, and mylar streamers.

Modelling the Chemical Attributes of Bird Repellants—Interdisciplinary studies by scientists from DWRC and the Monell Chemical Senses Center have shown that the effectiveness of bird repellants is associated with *basicity*, the presence of (1) an electron-donating group in resonance with an electron-withdrawing carboxylic group on a phenyl ring and (2) a heterocyclic ring in the same pi cloud as the phenyl ring. Of the benzoic acid derivatives tested, methyl, ethyl, dimethyl, and linalyl anthranilate, as well as anthranilic acid and 4-ketobenztriazine, were repellent to birds. Models predicting repellancy will permit the efficient identification and development of ecologically sound, nonlethal, taxa-specific repellants to be used for animal damage control and wildlife protection.

Reducing Bird Damage to Sprouting Rice—Several species of blackbirds, particularly red-winged blackbirds congregating in large spring roosts, can cause extensive damage to sprouting rice. U.S. Department of Agriculture (USDA) economists estimate that losses to rice growers reach $3.7 million annually. The chemical toxicant DRC-1339 has been used in the past to reduce blackbird populations near roost sites. However, the Environmental Protection Agency (EPA) has concerns about its effectiveness and hazards to nontarget birds feeding in baited areas.

During March and April 1991, rice baits containing DRC-1339 (2 percent active ingredient) were evaluated on blackbird staging areas near a 4.7-million-blackbird roost in Evangeline Parish, LA. During the prebaiting period, blackbirds consumed 5,900 lb of untreated rice from 9 bait sites within 2 miles of the roost site. During the treatment period, blackbirds consumed 4,600 lb of brown rice treated with DRC-1339. Based on a consumption rate of 28 particles per bait-site visit, an estimated 3.5 million blackbirds consumed treated baits. Thirteen days after baiting commenced, the roost population dropped from 4.7 million to 45,000.

Center scientists found that the rice baits treated with DRC-1339 caused no mortality to nontarget birds, such as savannah or white-crown sparrows, that were present on bait sites during baiting. Birds that could be susceptible to baits treated with DRC-1339 (e.g., mourning doves) were not observed on any baited site until after the baiting program was concluded.

In 1992, research was initiated to expand the possible use of DRC-1339 baiting for reducing sprouting rice damage by blackbirds roosting in coastal marshes in Vermilion Parish, LA. Because of the difficulty in attracting coastal roosting blackbirds to levee bait sites, Center scientists, with the assistance of biologists from APHIS' Animal Damage Control (ADC) unit, evaluated the effectiveness of "simulated rice fields" for attracting blackbirds to bait sites on levees. The potential effectiveness and nontarget hazards of DRC-1339 baiting for reducing spring-roosting blackbird populations under these conditions was also assessed. Eight of nine simulated rice fields, each consisting of prepared rice fields seeded with approximately 200 kg of dehulled (brown) rice, were effective in attracting blackbirds to fields and bait sites on adjacent levees. Most consistent blackbird use occurred at six fields located on or near blackbird flight paths to and from coastal roosting areas. Approximately 22 percent of these flightline blackbirds visited simulated fields.

From their assessments of 8 baited sites, Center scientists estimated that blackbirds consumed from 25 to 112 kg of bait treated with DRC-1339 per site during 4 to 18 days of baiting. Theoretically, if 432 kg of treated bait were consumed, approximately 500,000 blackbirds would have been killed. In response to baiting and migration, blackbird roosting populations in the treated area were reduced by approximately 70 percent. Yet for blackbird roosting populations in one untreated control area, reductions exceeded 90 percent, precluding any inferences about treatment effects.

Although 28 nontarget species, primarily shorebirds, were observed in simulated rice fields at a rate of 20.2 birds/h, baiting only levees and field edges appeared to limit nontarget bait exposure. Species such as killdeer, meadowlarks, and cardinals were observed at a rate of 0.5 birds/h on levees and field edges, significantly less than their rate of appearance in actual fields. Based on these data and except for cardinals (two of which were found dead), nontarget exposure on levee bait sites appeared minimal.

Reducing Blackbird Damage to Seeded Rice—The repellancy of a new insecticidal seed treatment, NTN-33893, was evaluated in cage feeding trials involving red-winged blackbirds and brown-headed cowbirds. Even at application rates well below those projected for insecticidal use, the compound effectively reduced bird consumption of rice seed. Additional trials are planned to investigate further the potential usefulness of this compound as a nonlethal means for controlling blackbird damage to seeded rice.

Evaluating Sucrose To Control Fruit-Eating Birds—Recent discoveries regarding bird feeding behaviors and digestive physiology suggest that conditioned aversions may develop in response to fruit chemistry. Major fruit-eating pests such as European starlings and American robins cannot digest sucrose, a minor component of blueberries, cherries, and other small fruits, because these birds do not have sucrase, the necessary digestive enzyme which splits the sucrose molecule. Developing techniques that would substitute sucrose for the simpler, digestible sugars naturally more prevalent in fruit (glucose and fructose) could reduce bird damage. This avenue was explored on two fronts in 1991: biochemical alterations of fruit chemistry and repellancy investigations.

Through a cooperative research agreement between the University of Florida and DWRC, fruit crop researchers at the university investigated enzymatic reactions that occur within blueberries that regulate sucrose breakdown. This research is continuing in hopes of determining biotechnological means to elevate the sucrose level in fruit to bird-deterrent levels.

Because ingestion of concentrated sucrose solutions makes sucrase-deficient birds ill, scientists have speculated that sucrose might represent an environmentally safe avian repellant. During 1992, Russ Mason and Larry Clark compared the repellancy of sucrose to that of methyl anthranilate (MA), a known avian repellant. They also tested different combinations of sucrose and MA to investigate whether repellancy could be enhanced by mixing the two compounds. The results show that birds strongly avoided MA in both feeding and drinking trials. Yet only light sucrose solutions were avoided, and then solely in drinking trials. No combination of MA and sucrose was as effective as MA alone.

Additionally, feeding experiments were used to assess the behavioral responses of fruit-eating birds to foods with high sucrose content. Robins and starlings avoided consuming aqueous solutions with more than 11.25 percent sucrose, mixed with less than 3.75 percent digestible glucose and fructose.

These data suggest that the development of high-sucrose fruits as special bird-deterrent cultivars is promising as an integrated pest management technique to deter feeding by some species of birds.

Repelling Birds From Fruit With Imidan®—The North American Blueberry Council conducted a DWRC-funded nationwide questionnaire survey to determine the extent of bird damage to blueberries. Tabulation and analysis of the responses suggested annual bird damage in excess of $8 million. The pesticide Imidan® (active ingredient, phosmet) is currently registered for use on numerous fruit crops. In feeding trials, starlings and cedar waxwings avoided Imidan-treated fruit mash at concentrations of 30 p/m and 100 p/m. These findings suggest that this currently registered insecticide treatment may be a useful component of strategies to control bird damage to fruit.

Two other bird-repellent materials yielded less satisfactory results. Although low applications rates of methiocarb (1.1 and 1.6 kg/ha) successfully repelled birds from blueberries in aviary trials, neither application rate provided adequate protection from bird damage in Michigan and Florida field trials. MA was applied at rates of 2.3 and 9.1 kg/ha to blueberries in flight pen and field trials in Florida. Even at the higher rate, neither of the two formulations tested was effective in reducing damage by birds.

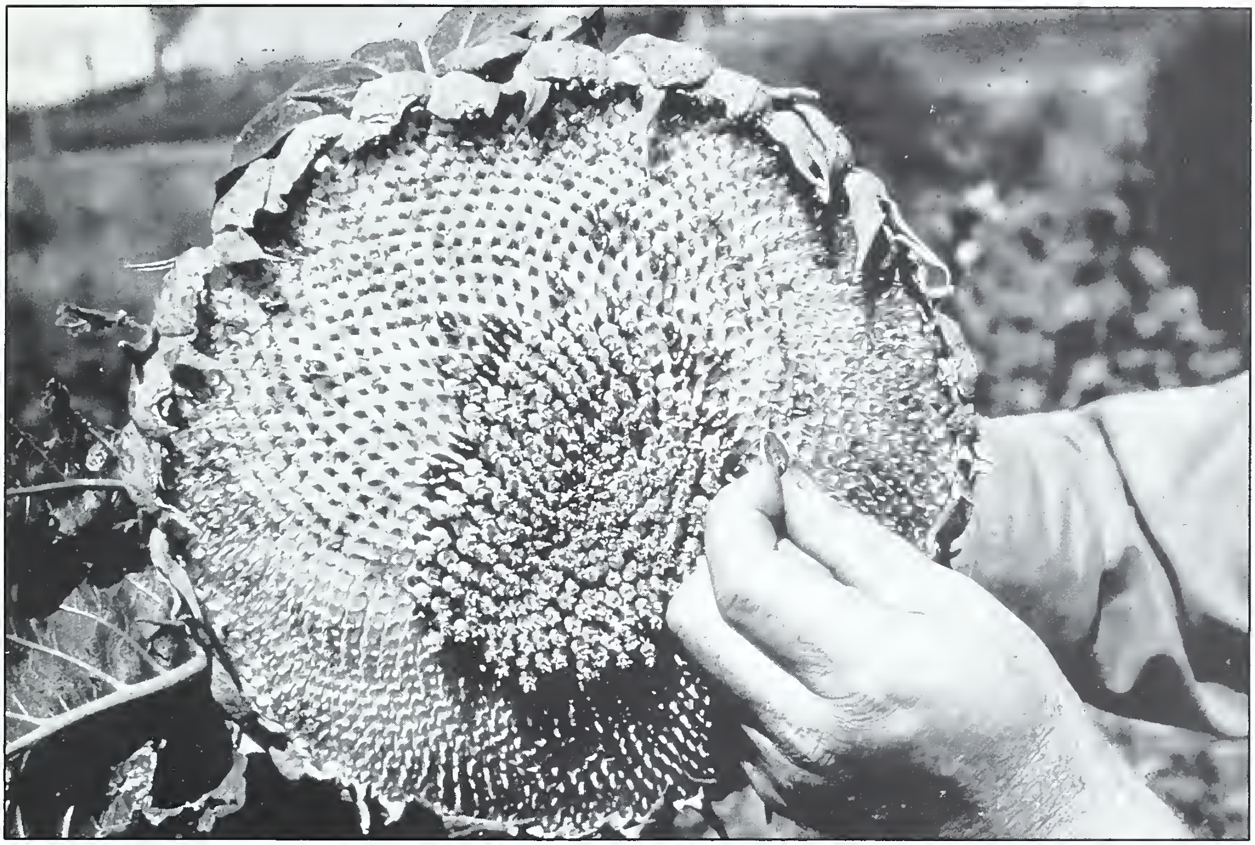
Birds and Blueberries—Blueberry and cherry growers continue to experience high fruit loss to birds in most areas of the United States. The use of frightening devices is costly, and they have limited effectiveness. The recent cancellation of Mesurol® for use on fruit came about in part because of concerns over residue levels. One approach to reducing residues is to lower the application rate. Center biologists evaluated Mesurol on blueberries in an aviary trial at application rates of 0.6, 1.1, and 1.6 kg/ha and in the field at 1.1 and 1.6 kg/ha. Biologists found that these application rates afforded limited reduction of bird damage to blueberries. However, Center biologists continue to evaluate other potential bird repellants such as MA and Imidan for use on small fruits.

In the summer of 1992, Center biologists evaluated two MA formulations (Bird Shield® and ReJeX-iT®) and Imidan in blueberry fields near Fennville, MI. Birds had consumed between 12 and 19 percent of the crop at harvest; however, results suggested that the rate of damage was reduced during the first 7 days posttreatment.

Reducing Blackbird Damage to Sunflowers in the North-Central States—Throughout Minnesota and the Dakotas, millions of common grackles, red-winged blackbirds, and yellow-headed blackbirds congregate in dense cattail marshes during midsummer, feeding on early ripening sunflowers. The value of annual sunflower losses due to blackbirds amounts to millions of dollars. Chemical repellants, mechanical scare devices, avicides, and altered cultural practices have been tested to reduce these losses. Each was found to have limitations because of high cost in relation to benefits, logistical considerations, limited effectiveness, and/or adverse environmental effects. DWRC scientists are testing new management techniques for reducing blackbird damage to sunflowers.

In current experiments, blackbirds are dispersed by removing or thinning cattails in their preferred roosting habitat, marshes. To accomplish this task efficiently, an EPA-registered aquatic herbicide (Rodeo®) is applied aerially to the cattails from fixed-wing aircraft. Research on the amount of habitat that must be altered to disperse blackbirds and thereby reduce sunflower damage is being conducted. In addition, the benefits of enhancing wetlands for other birds, especially waterfowl, through the use of interspersed vegetation and water are being assessed.

In August 1989, cattails in four marshes used by large populations of blackbirds were aerially sprayed in strips with Rodeo herbicide at 3.0 qt/acre. This rate was very effective for killing mature stands of cattails. Blackbirds did not roost in these marshes during 1990, 1991, or 1992. Populations of soras and Virginia rails, marsh wrens, waterfowl, and shorebirds were used to indicate possible effects caused by the application of Rodeo. The numbers of marsh wrens, soras, and rails, which depend on dense vegetation, declined



significantly between 1989 and 1992. The numbers of waterfowl and shorebirds remained the same.

In 1990 and 1991, 24 marshes were selected to (1) test the effectiveness of removing cattails to discourage blackbirds from roosting, (2) determine the effect of altering cattail marshes on nontarget avian populations, and (3) determine the effect of Rodeo on aquatic organisms. In July, strips of cattails in varying widths were sprayed with Rodeo across four marshes. Eight untreated marshes served as controls. Few blackbirds roosted in the treated marshes in 1992. Sunflower damage was minimal (< 3 percent) in sunflower fields surrounding treated and untreated marshes, making the effectiveness of cattail management difficult to evaluate. Numbers of marsh-dwelling birds observed, density of cattails in treated marshes, and the amount of sunflower damage surrounding test marshes will be analyzed.

Preliminary research on the development of a computerized mapping and imaging system to assess the effects of herbicide sprays on marsh vegetation began in 1991 and continued in 1992. Aerial photos were taken of 45 marshes treated with herbicide and 12 control (untreated) marshes. Ultimately, the system will be used to predict likely blackbird roost sites and to pinpoint areas of the marsh preferred by blackbirds.

North Dakota State University scientists have developed a bird-tolerant hybrid sunflower containing morphological features that thwart blackbird feeding. Features that may make sunflower heads less accessible to feeding blackbirds include concave heads facing downward, thicker hulls, long head-to-stem distances, and long, inward-pointing bracts. Completed research showed that these morphological traits are consistent among planting environments. Thus, hybrids possessing these traits can be developed for commercial use. Experiments have been conducted whereby captured red-winged blackbirds are fed whole sunflower heads showing various morphological features. It appears that concave-shaped or nearly flat heads facing the ground are the most effective for conferring bird resistance. A commercial hybrid bird-tolerant sunflower should be available within 3–4 years.

Development and Testing Rodenticides—DWRC researchers conducted a study in Texas to evaluate strychnine bait concentrations for control of the plains pocket gopher. Strychnine baits were applied by hand, and pocket-gopher mortality was determined by monitoring radio-equipped animals after treatments. The highest mortality occurred at the 0.75-percent concentration rate. DWRC submitted a final report regarding these data to EPA in 1992.

Laboratory studies of cholecalciferol as a rodenticide for use with northern pocket gophers were completed. Cholecalciferol concentrations as low as 0.01 percent are effective.

In laboratory studies, bromethalin grain baits were evaluated for black-tailed prairie dogs. The prairie-dog mortality data suggested that additional testing of this compound is desirable.

In cooperation with the State of Nevada, strychnine–alfalfa baits were formulated with a 3.2-percent strychnine concentration and were tested on Townsend pocket gophers in the laboratory. Data were inconclusive, and a field test scheduled for September 1991 was canceled. Additional testing with a reformulated strychnine concentrate has begun.

Evaluation of Strychnine Bait for Control of Mountain Beaver—Field evaluations of operationally applied, pelletized strychnine baits for control of mountain beavers on forest lands showed that at three experimental concentrations, strychnine had very little effect on mountain beavers. Evaluations on 24 study areas in Washington and Oregon indicated that the beavers readily take bait from burrows but apparently do not eat it. Pen studies at Olympia showed that one baited pellet (with 0.9 percent strychnine) was lethal but was not readily eaten. The manufacturer (Orco) does not plan to renew registration of the bait pellets for mountain beaver. There appears to be a significant correlation between telemetry evaluations of this pelleted bait, which showed good efficacy when it was placed where radio-collared animals were known to be active compared to poor efficacy for operational evaluations where the actual locations of the mountain beavers were unknown to the people applying bait.

Evaluation of Diphacinone Bait Blocks for Pocket Gopher Control—Radio telemetry and operational evaluations of registered paraffin bait blocks containing diphacinone for control of pocket gophers and pocket gopher reinvasion indicated that there was no reduction of reinvasion within 6 months or 1 year after this bait was applied to forest lands in southwestern Oregon. Radio telemetry applications, including the use of transmitters embedded in bait blocks, showed that blocks were fed on and were transported inside burrow systems. There was less control, however, of radio-collared pocket gophers with the diphacinone blocks than with registered strychnine-treated oat bait used for comparison (62 percent *v.* 72 percent). Overall control after 1 month with diphacinone was 36 percent, versus 61 percent with strychnine bait. Alternatives to baiting are being sought because of possible impacts on threatened or endangered species associated with lands under reforestation.

Evaluation of Cholecalciferol Bait for Pocket Gophers—Cholecalciferol-treated oat bait (0.15 percent active ingredient) was found effective against radio-collared pocket gophers in a tree seed orchard near Olympia, WA. A followup baiting of control animals with equal parts of untreated oats and cholecalciferol-treated oats was also effective.

Several pocket gophers in the study area were taken by avian predators. Further evaluation of cholecalciferol bait is indicated if sufficient data are developed to assure that no hazards exist for raptors and if the food base for threatened raptors is not jeopardized by baiting rodents on forest lands.

Alternatives to Lethal Baits for Mountain Beavers in Forests—DWRC researchers conducted studies of trapping and habitat modification by mechanical thinning and by use of herbicides on forest plantations damaged by mountain beavers. Evaluation of the removal of mountain beaver nests indicated that reinvasion of these systems is delayed several years, possibly long enough to establish new plantations. The initial herbicide applications applied to mountain beaver habitat were not effective in reducing growth of targeted vegetation.

Response of Mountain Beaver to Conspecifics in Their Burrow System—Artificial burrow systems were constructed to study interactions among mountain beavers. Encounters within the system were agonistic, and resident animals aggressively evicted intruders. Though mountain beavers exhibited scent-marking behaviors, the marks did not prevent intruders from entering and exploring occupied burrow systems. We speculate that marking serves to enhance the territorial confidence of the established mountain beaver.

Relative Intake of Selective Forage Species by the Mountain Beaver—Foraging by mountain beavers is economically important because it hinders reforestation efforts in the Pacific Northwest. Species of harvested forage have been identified through observational studies and stomach analyses. Unfortunately, scientists know little about why mountain beavers select these plants. In an ongoing study, attempts were made to identify factors that influence the foraging habits of mountain beavers. Mountain beavers are periodically offered a variety of plants from which to forage for food and/or nesting material. Relative changes in which plants are selected by mountain beaver may reflect changes in a plant's nutritional constituents or chemical defenses. A cursory review of the data reveals that conifers are taken less frequently in the spring and summer than they are during the fall and winter. Conversely, red alder is taken more often in the spring trials than in the winter trials. Foxglove and ginger are generally avoided, while mountain beaver routinely select for salal, cat's ear, sword fern, bracken fern, and red huckleberry.

Effects of Predator Odors on Feeding in the Mountain Beaver—DWRC investigators examined mountain beaver ingestion of food from bowls scented with mink anal-gland secretion or with urine from a number of predator species. Beavers ingested apple indiscriminately from unscented bowls, from bowls scented with the urine of an unfamiliar herbivore (domestic guinea pig), and from bowls scented with butyric acid. When beavers were given choices between apple offered in a bowl scented with secretions of a mink's anal gland and a bowl scented with butyric acid, the beavers ate significantly less apple from the predator-scented bowls. When the mountain beavers were offered apple from bowls scented with urine from a prairie vole and from bowls scented with mink, coyote, or domestic dog urine, all predator urines reduced ingestion. Habituation to the odor of coyote urine was investigated by measuring ingestion of dry pellets during continuous exposures to the urine for 5 days. During this period, significantly less chow was ingested from bowls scented with coyote urine than from control bowls, indicating a lack of habituation to the predator scent. We conclude that the predator scents tested in this study act as natural repellants. Their ability to control browsing damage by mountain beavers is being explored.

Potential Repellants To Prevent Mountain Beaver Damage—Mountain beaver damage to trees in the Pacific Northwest is economically serious. At present, few strategies are available to control damage, and new chemical repellants would have considerable utility. In the present experiments, we treated Douglas-fir and salal clippings with mink urine, coyote urine, orthoaminoacetophenone, or denatonium benzoate and presented them to mountain beavers. All treatments significantly reduced damage to salal. Mink and coyote urines appeared to produce the strongest effects. Mink and coyote urines were also the only treatments to significantly reduce clipping of Douglas-fir seedlings.

Rodent Avoidance of Coyote Urine Is Dependent on the Predator's Diet—Sulfur-containing odors attract carnivores and repel herbivores, most likely because sulfurous odors are produced during the digestion of meat. To study why sulfur affects animals this way, DWRC scientists at the Olympia, Philadelphia, and Logan field stations set up an experiment involving mountain beaver and two species of mice. All the animals were presented with urine from coyotes fed red meat or cantaloup. In each case, the urine from cantaloup-eaters was less aversive than that from meat-eaters. Subsequent tests suggested that these results were not due to dilution of urine. These data were consistent with our view that carnivores produce general species-inspecific cues that repel herbivores. This information may also lead to the development of rodent repellants.

Assessing Pocket Gopher Activity—Directly observing the activities of a burrowing animal like the pocket gopher is virtually impossible. However, observations are necessary when evaluating whether a control program is needed or has been successful. Two techniques have been used for assessing pocket gopher activity, the plot-occupancy and open-hole methods. The plot-occupancy method involves establishing a plot containing signs of pocket gopher activity, erasing (levelling) all signs within the plot, and returning in 48 hours to check for new signs. If new signs are found, then the plot is considered active. In the open-hole method, two burrows are located (using a metal rod) and opened. If they are plugged within 48 hours, the plot is considered active.

Although both measurements are highly specific for pocket gopher activity, no information has been available concerning how sensitive they are to pocket gopher activity or how well the two measurements compare. DWRC scientists conducted a study in Idaho's Targhee National Forest to answer these questions and determine the plot sizes required for measuring activity and whether the use of the open-hole measurement might affect results from the plot-occupancy measurement. The open-hole method was found to be more sensitive to pocket gopher activity and much more accurate in measuring it than the plot-occupancy method. There was no indication that the open-hole measurement affected results from the plot-occupancy measurement when utilized on the same plot.

Mammal Control—Workers in DWRC's analytical chemistry section developed analytical methods for several pesticides in 1991–92. The composition and purity of zinc phosphide technical materials were investigated, and grain bait formulations were assayed to confirm the concentration of zinc phosphide in the formulations before and during laboratory and field studies. Methods development studies were conducted to determine low levels of zinc phosphide residues in tissue, and the section participated in a laboratory pilot study by determining zinc phosphide and phosphine residue levels in rodent carcasses.

Section chemists studied the rodenticide strychnine alkaloid in the laboratory and measured residue levels in pocket gopher carcasses collected during field studies. DWRC personnel developed new analytical methods for a variety of strychnine bait formulations used in laboratory feeding trials, in ADC operational programs, and in other wildlife-control efforts in several States. Highly accurate and precise chemical data were obtained from formulated bird diet samples containing strychnine. The diets were used in a 28-day avian reproduction pilot study by scientists from Bio-Life Associates, Ltd. Section chemists also developed analytical methods for the two-component gas cartridge formulation used for rodent control. The cartridge formulations were assayed to confirm that the correct quantities of each active ingredient, sodium nitrate and charcoal, were present.

Trapping Rats in Macadamia Orchards—During the 1990–91 and 1991–92 crop cycles, we evaluated snap trapping for reducing roof rat populations and controlling damage in a Hawaiian macadamia orchard. More than 2,000 rats were captured during the study. Total annual crop damaged by rats varied from 0.36 to 1.34 percent in the trapped sections and from 1.71 to 3.62 percent in the control or untrapped sections. Trapping had no effect on yields, however; the number of nuts, mass per nut, and the total mass of undamaged nuts did not differ between the trapped and control sections.

Results suggest the need to examine crop yield more closely when assessing methods for managing rodent infestations in orchards. The commonly used indices, based on rodent activity and proportion of nuts damaged, may overestimate the impact of rodent depredation and exaggerate the effectiveness of control measures in macadamia orchards.

Testing Rodenticides for Control of Agricultural and Rangeland Rodent Problems—No-choice feeding trials were conducted with individually caged animals to evaluate the efficacy of cholecalciferol for killing select species of field rodents. Cholecalciferol appeared promising for northern pocket gophers, plains pocket gophers, thirteen-lined ground squirrels, spotted ground squirrels, Columbian ground squirrels, Richardson's ground squirrels, and Polynesian rats. Low mortality indicated that cholecalciferol may not be effective for black-tailed prairie dogs or Hawaiian populations of Norway rats and roof rats.

Zinc phosphide-treated oats are the rodenticide bait most commonly used to reduce rat populations in sugarcane fields and macadamia orchards in Hawaii. However, results of baiting programs have been inconsistent, especially with Norway rats. DWRC investigators conducted a field study to evaluate prebaiting with untreated oat groats to enhance the efficacy of zinc-phosphide-treated oats for controlling rats in sugarcane fields. Prebaiting improved efficacy but was not cost effective.

No-choice laboratory feeding trials compared the efficacy of three commercial pelleted baits containing zinc phosphide with that of zinc phosphide oats. Hopkins Zinc Phosphide Pellets were the most effective of the four baits evaluated for killing all three species of rats present in Hawaii. Weatherability tests indicated that this Hopkins product also is most resistant to degradation in Hawaii's moist conditions, which are typical of many areas where sugarcane is grown.

In vitro studies have shown that lauric acid, a naturally occurring short-chain fatty acid, has the potential to enhance the efficacy of warfarin and other anticoagulant rodenticides. In vivo laboratory tests were conducted to explore the potential of lauric acid as a bait additive for reducing the amount of toxicant needed to kill each of three rat species that are agricultural pests in Hawaii. Results indicate that lauric acid has limited potential as a bait additive.

Assessing Movement Patterns of Rats in Macadamia Orchards—A radio telemetry study was conducted to determine nightly movement patterns of rats in a macadamia orchard, to detect seasonal differences in these movements, and to relate seasonal differences to the abundance and maturity of nuts. During each of 3 periods of the crop cycle, approximately 20 roof rats were captured and fitted with radio collar transmitters. Nightly movements of the rats were monitored during nine nightly tracking sessions over a course of 3 weeks. Occasional daytime readings were taken to monitor diurnal activity, locate nests and daily resting places, and confirm suspected mortality.

Most rats rested in burrows during the day, emerged shortly after sunset to feed in the canopy of macadamia trees, and returned to the same burrows shortly before sunrise. A few rats remained in trees during the day. During peak harvest, when mature nuts are most abundant, most rats stayed within 5–10 trees of their daily resting burrows. Nightly movements appeared to be more extensive during peak flowering and peak nut immaturity, perhaps in response to the reduced availability of nuts. Only limited movement between the orchard, surrounding windbreaks, and noncrop areas was observed.

Results from this study will help managers devise more effective strategies for controlling rats in macadamia orchards. Knowledge of seasonal and nightly movement patterns of rats in orchards could help determine optimum timing and placement of rodenticide baits, traps, and other control measures.

The reproductive condition and stomach contents of rats captured in a macadamia orchard at various times throughout the year were also analyzed. Pregnant and lactating rats were found during all months. Macadamia nuts comprised the majority of the diet for all rats examined. The results indicate that even during periods of low nut availability, rats find sufficient food within orchards to sustain themselves and even reproduce.

Assessing Rat Damage to Sugarcane—Statistical support is integral to any research program. Experimental design, the collection and analysis of data, and the forming and reporting of inferences from a study all depend on statistical support. Traditional statistical theory and methods are often difficult or impossible to apply to studies in wildlife research. Thus, it is essential that new statistical methods be developed and existing methods be assessed.

Estimating the density of stationary objects in a given area is a vital component for many wildlife studies. Quadrat or plot sampling is an accurate, robust method for producing density estimates. However, for many studies where the objects are sparse or the environment difficult to work in, quadrat sampling is too labor intensive or expensive to be practical. For this reason, DWRC statisticians developed plotless sampling methods. The sampling involves measuring distances between random points and the sampled objects and/or distances between the objects. This form of sampling can be much less labor intensive than quadrat sampling. The theoretical properties for the plotless methods generally have been restricted to randomly distributed objects, even though most spatial patterns in nature involve clumping of objects. Another drawback with the use of plotless methods is that there is little information to compare the performance of the many plotless density estimation methods in a diversity of situations.

In an effort to define and compare the statistical estimation properties of the plotless methods, DWRC conducted a large computer simulation study involving established plotless density estimators plus some new ones developed at DWRC. The simulation study looked at nearly 100 combinations of different object densities, spatial patterns, and sample sizes to obtain a thorough understanding of which methods would provide robust estimation in a variety of circumstances. Of the 26 plotless methods studied, 8 provided adequate estimation results. Three of these eight appear to be most practical when applied in field situations where quadrat sampling is unsuitable. These include the variable area transect, where a strip transect is followed until three objects are encountered; the ordered distance estimator, where the distances from random points to their three nearest objects are measured; and an estimator developed at DWRC's Hilo, HI, field station, which uses three search areas for estimation. The search areas are from a random point to the nearest object, from the nearest object to its nearest neighbor, and from that object to its nearest neighbor. This last estimator is the one recommended to and applied by the Hawaiian sugarcane industry for assessing levels of rat-caused damage. The results of the simulation study already have been applied during animal damage studies in Australian sugarcane fields.

Endangered Species

Depredations of California Least Terns by Ravens—Fiscal year (FY) 1992 was the final year of U.S. Navy-funded research to investigate raven ecology and to develop and evaluate methods to reduce raven predation on the eggs of the endangered California least tern at Camp Pendleton Marine Base in California. Captive fish crows were tested for their responses to repellant-treated quail eggs. The most effective repellant proved to be methiocarb that was injected inside the test eggs, combined with a topical treatment of methyl anthranilate on the outside.

These findings were then applied in a field evaluation of aversive conditioning to deter egg predation by common ravens. Responses of the ravens to the repellant-treated test eggs were encouraging in that all learned to avoid the eggs after 3–4 days' exposure. Yet the egg avoidance behavior appeared to be site dependent. Therefore, in order to be maximally effective, application of this nonlethal predation control technique should focus on the actual tern nesting sites. DWRC's analytical chemistry section evaluated the stability of methiocarb-treated egg baits and determined that the concentration of active ingredient decreased only approximately 0.1 percent after 7 days under typical environmental conditions.

The ecology studies produced valuable information on raven behavior, nesting habits and success, home-range and movements of radio-instrumented birds, and effective methods of capturing and marking ravens. During the 4-year study, 219 breeding adults, nonbreeding adults, and juveniles were captured using 6 different methods. The most effective capture methods were an electronically controlled, remotely fired cannon net and a modified Australian crow trap, both using a live raven decoy. Each captured bird was marked with a colored, numbered patagial tag; 67 birds were also fitted with radio transmitters, attached by either a backpack harness or tail mount.

Marked or instrumented juveniles tended to leave their natal areas about 2 months after fledging, when they formed or joined large wandering bands of ravens foraging for food. Some birds disappeared from their natal area and were seen up to 50 miles away. Other juveniles remained within a 15- to 20-mile radius of their natal area. After the breeding season, breeding adults tended to remain in the vicinity of former territories until the next nesting season. We found no incidences of juveniles displacing breeding adults in our study area after the juveniles reached breeding age.

The most useful behavioral information obtained showed that nesting ravens are highly territorial and tenacious in defending their territories from other corvids. The data also show that raven predation on tern eggs in Camp Pendleton colonies is minimal. In fact, none has occurred in some years. Therefore, if territorial birds nesting near a tern colony are left undisturbed, their territorial defense activity can be used to protect a tern colony from intruding corvids as long as the defending ravens do not develop a propensity to consume tern eggs themselves.

Nuisance, Safety, and Health Concerns

Reducing Bird Hazards to Aircraft—Collisions between birds and aircraft pose a significant threat to human safety and cost the air transport industry and the military millions of dollars annually. DWRC entered into a cooperative agreement with the Federal Aviation Administration (FAA) in 1992 to pursue several areas of research to reduce the incidence of bird–aircraft collisions.

Landfills located near airports can create hazardous conditions for aircraft because birds, especially gulls and starlings, are often attracted to these sites to forage and soar. DWRC biologists are studying bird use at and around various types of landfills (e.g., general, composting, trash transfer stations, ash) to assist the FAA and other regulatory agencies in making decisions about the siting and operation of landfills near airports. For example, our initial studies done in 1991 and 1992 indicate that landfills which compost yard waste do not attract birds and can be located near airports.

Gulls and other birds are often attracted to airports after heavy rains to drink and bathe in temporary pools of fresh rainwater, especially in saltwater coastal areas. Pen trials have shown that methyl anthranilate (MA), a nontoxic chemical used as a human food flavoring, repels birds from water when added in low concentrations. In 1991, field evaluations conducted at John F. Kennedy International Airport in New York City showed reduced bird activity in water treated with MA. In 1992, field tests at a landfill also showed reduced bathing and drinking activity by gulls in pools of water treated with MA formulations. Efforts are currently underway to register MA in several formulations as a nontoxic bird repellant.

Alpha-chloralose (A-C), which depresses the cortical centers of the brain, has been used as an anesthetic for animals, a hypnotic drug for humans, a capturing drug for wild birds being researched, and a toxicant for reducing wildlife populations. Our laboratory and field research over the past 3 years has demonstrated the effectiveness and safety of A-C for capturing nuisance geese, ducks, coots, pigeons, and gulls.

From 1988 through 1992, A-C was successfully used in the United States to immobilize and remove more than 2,500 nuisance waterfowl and pigeons from 30 commercial, industrial, agricultural, and residential sites, including golf courses, pools, feedlots, and airports. Our research has shown that A-C can serve as a humane, environmentally safe, and publicly acceptable means of removing certain bird populations from airports and other locations where their natural activities conflict with human endeavors.

Based on our research findings, the U.S. Food and Drug Administration has issued an Investigational New Animal Drug Agreement for A-C use by Federal ADC biologists nationwide for capturing problem birds (waterfowl and pigeons) at airports and other sites.

In a cooperative study with the U.S. Air Force, DWRC biologists determined the density of 12 species of birds ranging in size from house sparrows (23 g) to Canada geese (4,000 g). Twelve birds of each species were measured. After feathers were removed, house sparrows, chickens, cowbirds, starlings, and common grackles all had body densities greater than 1.0. Mallards, rock doves, Canada geese, turkey vultures, laughing gulls, herring gulls, and ring-billed gulls all had densities less than 1.0. Mean densities ranged from 0.846 for herring gulls to 1.050 for house sparrows. These density data, the first ever collected for birds in North America, will be used by the Air Force and air transport industry in designing aircraft components more resistant to damage from bird strikes.

Reducing Turf Damage by Canada Geese With DRC-156— Populations of Canada geese in U.S. flyways have increased an average of 150 percent in the last 10 years. Although these increasing populations are a positive step in the conservation of waterfowl, Canada geese are now frequently implicated in habitat destruction, crop depredation, nuisance problems, and incidents threatening the safe operation of aircraft. Most management techniques have limitations due to cost, logistics, and/or effectiveness. These limitations have stimulated efforts to develop chemical repellants that are effective and economical but also safe for target and nontarget species. DRC-156 is one such promising candidate that is repellent and aversive to waterfowl, specifically Canada geese.

In 1991, Center scientists evaluated the repellancy of DRC-156 to Canada geese on a 1-acre grass enclosure. Three application rates, (4, 8, and 16 lb/acre) were compared. All application rates significantly reduced the use of treated grass plots within the enclosure. However, the duration of effectiveness was dependent on the application rate: 4, 8, and 16 lb/acre repelled geese for 12, 24, and 40 days, respectively.

In a large-scale field test, DRC-156 applied at 8 lb/acre to 5 grass sites ranging in size from 3 to 8 acres was effective in causing geese to avoid treated areas up to 23 days posttreatment. Center researchers believe that these data provide evidence that DRC-156 could be a viable tool in reducing conflicts with waterfowl, and specifically, Canada geese.

Methyl Anthranilate Beads for Taste Aversion From Ordnance Residues—During the past 10 years, waterfowl have been found dead during the fall and spring migrations in Eagle River Flats, a 1,000-ha salt marsh at Fort Richardson, AK. The U.S. Army has used this marsh since 1945 as an artillery impact area. Waterfowl mortality has been attributed to the ingestion of white phosphorous residues in pond sediment.

Center biologists believe one method that could potentially reduce waterfowl mortality is the application of a nonlethal chemical repellant to the bottom sediment. Methyl anthranilate (MA) entrapped in 2- to 3-mm beads was tested at the site. The beads were designed to burst in the mouth of feeding waterfowl. This research complements other research efforts attempting to register MA as a waterfowl repellant with the EPA. Evaluations of several MA bead sizes and concentrations produced positive results. Further testing is planned.

Livestock

Repelling Birds From Feed Troughs—Blackbirds, and especially starlings, can be a serious economic concern to livestock producers because these birds often consume livestock feed. Such birds also act as vectors of livestock disease. Although MA has been shown to reduce feed consumption by starlings under laboratory conditions, effective field application methods and rates have not been determined.

Under simulated field conditions, MA dissolved in ethanol at a ratio of 75:25 (Bravo™ Bird Flavor) was surface-sprayed on poultry pellet feed at selected application rates to evaluate its potential and this application method for reducing feed consumption by birds. Results suggest that birds avoided treated feed troughs even after the treated feed surface was removed, and the 8-g application rate (48 g/m^2) consistently reduced feed consumption by 89 to 99 percent during three trials at two sites. Implications of these trials suggest that surface spray treatments of this MA–ethanol formulation can be a cost-effective control method for reducing damage caused by blackbirds and starlings at livestock feedlots.

In 1992, further studies with surface spray treatments of feed were conducted, comparing a ReJeX-iT MA formulation to the MA–ethanol formulation used in 1991. Although the ReJeX-iT formulation appeared to be as effective as the MA–ethanol formulation in reducing feed consumption, neither was consistently effective. Further testing of these and other formulations is needed to define the parameters necessary to achieve consistent repellancy.

Evaluating Padded Jaw Traps for Capturing Coyotes—Leghold traps are an important tool used by the ADC program for controlling damage caused by coyotes. Concern for reducing the amount of injury to restrained animals led to the development of padded traps. However, early prototypes and commercial models had reduced performance in capturing and holding coyotes. Investigators from the Center's predator control research section compared the performance of Woodstream Corporation's latest version of the No. 3 Soft-Catch® padded trap with three other unpadded trap types routinely used for capturing coyotes (the No. 3 NM® long-spring, the No. 3 coil-spring, and the No. 4 Newhouse long-spring). Field work was conducted in southern Texas during January and February of 1989 and 1991 when trapping conditions were generally favorable. In all, 118 coyotes were captured and held in the 4 trap types during the tests.

Capture rates did not differ among the long-spring, coil-spring, and Soft-Catch traps. Improved performance of the Soft-Catch trap was attributed to mechanical improvements in the trap and to the trappers' following the specialized trap-setting procedures recommended by Woodstream. Further testing of the Soft-Catch trap in other States with different environmental conditions and soil types will determine its suitability as an effective control tool for use by ADC personnel.

Delivering Control Agents to Predators—Baiting techniques for carnivores have been studied to deliver a variety of control agents that require ingestion, including toxicants, reproductive inhibitors, aversive agents, and vaccines. One problem encountered in earlier studies of baiting methods for coyotes was consistently low bait consumption, assessed by the use of nontoxic tallow baits containing marking agents. Field evaluations of low-density applications of small baits have examined effects of bait type, placement, density, season, and removal by nontarget species (primarily magpies and small rodents).

Seasons greatly affect coyote acceptance of baits. One DWRC study revealed that baits, placed at a density of 5 per square mile, were eaten by only 20 percent of coyotes in the spring and 28 percent in the summer. Bait acceptance rose to 42 percent in the fall and 67 percent in the winter. In another study done during the winter with baits placed at 2 and 20 per square mile, 60 and 67 percent of examined coyotes had eaten the baits.

Baits elevated on wires above the ground remained available four times longer than ground-placed baits because the elevated baits were less available to rodents. However, coyotes also avoided the elevated baits. Tests suggested that bait removal by birds and small mammals could be reduced by covering baits with small rocks that could be removed by coyotes but not by smaller animals. Bait acceptance by higher proportions of locally active coyotes was enhanced by selective placement in areas of high activity, careful placement of baits using techniques similar to those for trap placement, use of superior coyote attractants, and placement during winter months. These ongoing studies indicate that significant proportions of locally active coyotes can be induced to consume small tallow baits and that nontarget animal exposure can be minimized.

Aquaculture

Determining Impacts of Double-Crested Cormorants on the Catfish Industry—In 1991, DWRC continued three field studies in the Mississippi Delta to provide data for a bioenergetics model of wintering cormorant populations and their impact on the catfish industry. One study was a monthly roost population census, conducted November through April under contract with the U.S. Fish and Wildlife Service's Cooperative Wildlife Research Unit. In another project, researchers collected birds at selected roosts to perform food-habit analyses. A full-scale telemetry study was also initiated in 1991 and continued in 1992, determining the movements and daily activity budgets of cormorants.

In 1991, average monthly cormorant populations at 12 active roost sites were similar to the previous year. Populations varied from less than 10,000 birds in November to more than 24,000 birds during late winter and early spring. In December 1991, as well as February and March 1992, Center scientists and ADC biologists conducted censuses of cormorant populations in the Mississippi Delta that showed population levels and trends consistent with those of 1989 and 1990.

Studies of the cormorant diet, initiated in 1990, were completed in 1991. Catfish comprised approximately 50 percent of the diet in both years. Catfish and gizzard shad were the only two important prey species, comprising more than 90 percent of the diet from all samples. Catfish composition in the diet varied between roost locations, from 14.3 percent for roosts near the Mississippi River to 74.5 percent for inland roosts in the heart of the catfish-production area. Diet also varied between sexes of birds and among months of the year. Catfish were most often consumed by male cormorants during the spring months in areas of highest catfish concentration.

A total of 59 cormorants were captured and fitted with transmitters during the winters of 1990–91 and 1991–92. Usable data were collected on 18 individuals that were tracked for a total of 400 hours over 36 days. The mean distance flown by cormorants from their night roost to their first foraging site was 15.7 km, and the mean distance flown from a foraging site to a day roost was 2.6 km. The analysis of daytime tracking data revealed that cormorants spend about 57 percent of their time roosting, 18 percent loafing in water, 18 percent foraging, and 8 percent flying.

Data from the above studies and elsewhere were incorporated into a bioenergetics model that predicted monthly energy and food demand of wintering cormorants in the Mississippi Delta study area during the winters of 1989–90 and 1990–91. Based on an average food demand of 504 g/bird/day, wintering cormorants were predicted to consume 939 and 842 metric tons of catfish during the winters of 1989–90 and 1990–91, respectively. Food demand in the form of specific catfish size-classes suggested that between 18 and 20 million fish would be consumed, or approximately 4 percent of the "standing crop" of catfish, annually. Based on the replacement cost of these fish, ranging in size from 10 to 23 cm, the annual economic loss to the catfish industry was estimated at between $1.8 million and $2 million.

Reducing Cormorant Depredations With "Scarey Man"— Various stationary scaring devices (propane cannons, scarecrows, old vehicles, etc.) are currently used by catfish growers in the Mississippi Delta to discourage cormorants. A new electronically controlled effigy-type scare device called "Scarey Man" showed promise as an additional tool. During its scare routine, the blaze-orange effigy inflates to its full height of 2.23 m, bobs up and down, and emits a high-pitched wail before collapsing.

The short-term effectiveness of Scarey Man in reducing cormorant numbers was tested in the late winter and early spring of 1991 in four split-plot tests at paired, adjacent catfish complexes. Each split plot consisted of a treatment and a control complex. The tests were preceded by either a 3- or 5-day pretreatment in which harassment patrols were conducted on both complexes. In three of the four tests, the Scarey Man treatment effect was superimposed over the regular harassment patrols that were conducted as often on the treated side as on the control side. The other test was an attempt to judge the effect of Scarey Man without the help of harassment patrols. Patrols were conducted only on the control complex during the treatment phase of this test. Placement of the Scarey Men resulted in immediate and drastic reductions in the numbers of cormorants flushed from the complexes in three of the four tests. In the one exception, the reductions were not as great or as lasting, probably because of the proximity of a cormorant day roost. Some signs of cormorant habituation to Scarey Man were evident in all tests except one. The dollar value of catfish saved was estimated to be an average of $125 per day.

During the late winter and early spring of 1992, a long-term trial of the effectiveness of Scarey Man was conducted in which 10 of the Men were deployed over a 141-ha complex for a 7-week period preceded by a 3-day pretreatment period. A 64-ha complex located 13.5 ha to the west served as a control complex. On average, four harassment patrols were conducted each day on each complex. Efforts were made to enhance the repellent effect of Scarey Men by dressing them more realistically, by substituting look-alike shooters for comparatively ineffective Scarey Men, and by concurrently using propane exploders.

In this trial, Scarey Man deployment resulted in an immediate, drastic, and permanent decrease in the number of cormorants flushed per day. Inexplicably, the same phenomenon (although not as pronounced) occurred at the control complex. Even so, the savings in fingerling catfish not consumed by cormorants as a result of Scarey Man use and enhancement was estimated at $107/day, including a $22/day cost for use of each Scarey Man. Efforts to reduce the residual population of 50–75 birds through enhancement of Scarey Man proved unsuccessful. Propane exploders did not appear to help.

The deployment of Scarey Man, in addition to regular harassment patrols, will be cost effective in reducing cormorant depredations, provided that the birds are feeding primarily on catfish instead of shad (a common trash fish). In the case of catfish fingerling operations where the presence of cormorants necessitates the use of harassment patrols, we recommend the use of Scarey Man and patrols.

Evaluating Exclusion Devices for Cormorants—Several overhead wire systems have been suggested for excluding cormorants from aquaculture facilities. But these systems pose engineering problems in spanning the long distances found in Mississippi catfish ponds (i.e., ponds 5–10 ha in size). Likewise, there is concern that an overhead system with its associated posts or stanchions would interfere with normal day-to-day fish-raising practices. Therefore, DWRC investigators tested a simpler system of parallel floating ropes within catfish ponds to determine its utility for preventing cormorant predation. The premise being tested is that ropes placed perpendicular to the prevailing wind may inhibit cormorants from landing on or taking off from the pond.

An evaluation of floating ropes was conducted in Mississippi from late January through early April 1992. The rope system, consisting of lengths of 1-cm yellow polyethylene rope and red foam floats spaced 6 m apart, was placed in the water and pulled across the pond using a small boat. The ropes were placed at 15-m intervals across the pond and staked perpendicular to the prevailing winds. Bird observations usually lasting 120 minutes on each pond were made 3 days a week between 0800 and 1200 hours during pretreatment and treatment periods. Only cormorants entering each pond during the observation period were recorded. The floating rope system was set on one of two adjacent ponds after an initial 2-week pretreatment period. The pond receiving the highest pretreatment bird pressure was initially selected to receive the ropes. The second pond served as an untreated control for 5 weeks when floating ropes were also placed on it. Numbers of cormorants entering the first pond decreased dramatically after the ropes were deployed. A total of 2.3 cormorants per minute entered this pond during the 2-week pretreatment period, whereas only 0.06 cormorant per minute entered during the next 5 weeks with the ropes in place. During these same time periods, cormorants entering the adjacent untreated pond remained fairly constant at 0.78 and 0.71 birds per minute. After ropes were put on the control pond, cormorant numbers decreased to 0.004 bird per minute and remained low for the rest of the test. Further evaluations of the floating rope system are planned to confirm these findings.

Assessing Great Blue Heron Depredations to Commercial Catfish—Catfish farming in Mississippi has now exceeded 40,470 water-hectares. Along with this tremendous expansion of the catfish industry have come increases in depredations by wading birds. One species of particular concern to catfish growers is the great blue heron, but its economic impact on the catfish industry is not clear. Depredation data are needed to justify control efforts and to determine the cost-effectiveness of candidate control strategies.

To examine the impact of this species, DWRC scientists collected 222 hours of observation data during daylight hours on heron populations and the food habits and foraging rates of these birds at catfish farms. Diurnal observations included complexwide counts of herons taken every 3 hours. Between these counts, individual herons were randomly selected for feeding behavior study. An individual was continuously observed for as long as it remained in view. Notes were taken on the number of fish caught; the species, size, and condition of the prey; and the time taken to subdue and swallow it. Herons were observed to take 125 live catfish, 35 dead catfish, and 291 other fish (mainly sunfish, shad, and gambusia). Thus live catfish made up 28 percent of the catch, dead catfish 8 percent, and other fish 64 percent. Based on these data, if a great blue heron fished 8 hours a day, it would take on average 4.5 live catfish per day.

Beginning in 1991, DWRC investigators studied heron depredations to catfish at night. But they found that nocturnal catfish feeding occurred only rarely. Only 1 live catfish and 1 dead one were recorded taken during this timespan. However, 381 other fish (probably gambusia) were taken.

In addition, the investigators completed food-habit analysis of 57 herons previously collected during daylight hours by ADC personnel under depredation permits. Results of these analyses suggested a diet of 31 percent catfish, 22 percent gizzard shad, 44 percent sunfish species, and 2 percent other fish.

Evaluating an Electric Fence Barrier—Wading birds, primarily great blue herons and great egrets, are responsible for a yet-undetermined amount of loss to the catfish industry in Mississippi. Although frightening devices (e.g., pyrotechnics, shooting, and propane exploders) have been used with mixed results, current research efforts have been directed at finding inexpensive means to exclude these birds from catfish ponds. In an initial study, horizontally placed perimeter netting made of plastic mesh did not prevent herons and egrets from feeding at catfish ponds. In 1991, a test of a two-strand electric fence barrier on two ponds (0.4 and 2 ha) showed more encouraging results. After the fencing was set up on the 0.4-ha fingerling pond, only 20 bird-minutes of wading bird activity were recorded at the water's edge during 21 hours (11 days) of observation. During 2.5 hours (5 days) on the same pond before the fencing was installed, 694 bird-minutes of activity were recorded. Similar results were observed on the 2-ha pond. A total of 480 bird-minutes of activity was recorded at the water's edge during 60 minutes of pretreatment counts, whereas no birds were seen during 7.2 hours of observation during the treatment period. These results prompted further replicated testing of this barrier system, which is currently underway.

International Cooperation

The Denver Wildlife Research Center has worked for many years with the U.S. Agency for International Development (AID) and other international organizations in support of developmental research to reduce vertebrate pest damage to agriculture in developing countries. Vertebrate pest field-station projects and outreach activities from the Center's scientists have worldwide applications.

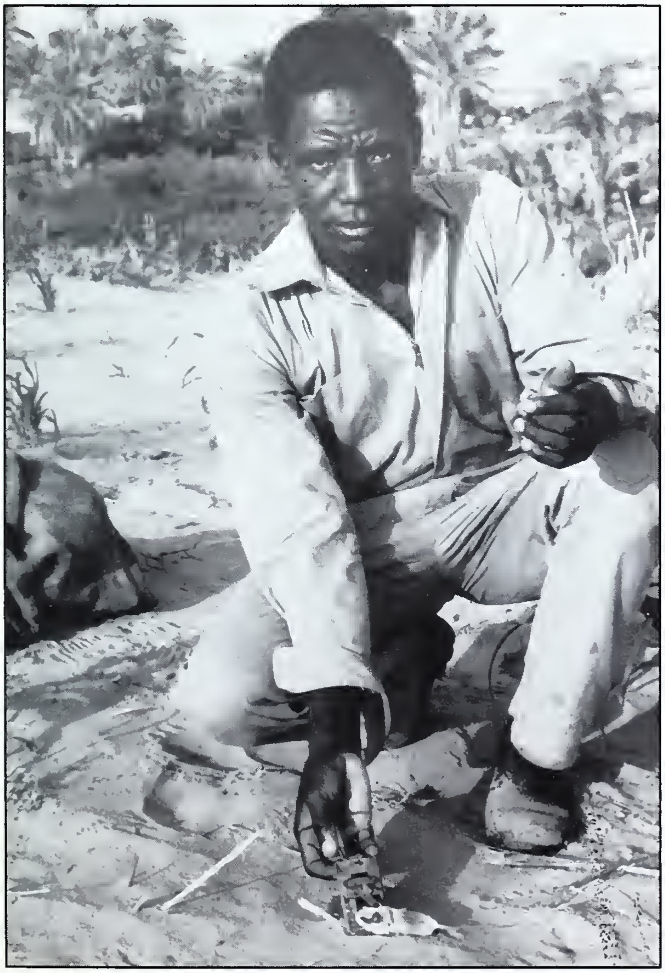
In May 1992, the Washington, DC-based Population Crisis Committee published the results of its study "International Human Suffering Index." This study ranks 141 countries on the basis of 10 indicators of human well-being, 1 of which is daily food availability. Of the 15 countries ranked as the worst places to live on Earth, DWRC has provided short-term assistance to 10 (Somalia, Mozambique, Haiti, Sudan, Ethiopia, Sierra Leone, Uganda, Guinea–Bissau, and Chad) and managed incountry field stations in 3 (Haiti, Sudan, and Chad). While increasing food availability is only one of many criteria necessary to reduce the level of suffering in these and other developing countries, this study shows that efforts like DWRC's are still very much needed for many of the world's poorest countries.

During fiscal years 1991 and 1992, the Center conducted 61 international consultancies utilizing 28 researchers to assess vertebrate pest problems in 26 countries; to conduct, review, evaluate, and coordinate present and future activities; to participate in training workshops; and to present technical seminars. During this same time period, nearly 7,900 documents were provided in response to requests from 89 countries. Personnel from DWRC's international programs research section received three awards during 1991 for exceptional sustained contributions in vertebrate pest management leading to increased agricultural production in developing countries. These included a unit award for superior service from USDA, an international honor award from the USDA's Office of International Cooperation and Development, and an honor award from APHIS.

Argentina and Uruguay—Under the terms of a binational Food and Agriculture Organization (FAO) of the United Nations project agreement, "Integrated Control of Bird Pests," DWRC provided or coordinated eight consultancies to help define bird pest problems and technical-assistance training needs in Uruguay and Argentina. Projects focused on major pest bird problems common to both countries in the Rio de la Plata region. These activities will lead to the development of a longer term project to help protect primary crops from serious bird damage. The major bird pests in both countries are the eared dove, the monk parakeet, the Picazuro pigeon, and the spot-winged pigeon. In addition, upland, ashy-headed, and ruddy-headed geese are a problem in Argentina. These birds damage several important crops in the region, including sunflowers, sorghum, corn, barley, wheat, soft fruits, and forage.

Bangladesh—Through funding by AID, DWRC had provided full-time, incountry technical assistance in vertebrate pest management to scientists at the vertebrate pest section of the Bangladesh Agricultural Research Institute from 1978 until August 1990. Since October 1991, DWRC has sponsored six consultancies in Bangladesh to test, implement, and evaluate an annual rodent control strategy as well as develop longer term research plans for rodents, jackals, and birds. Additional technical assistance from DWRC to the institute is planned until June 1993, when this project will end.

Chad—The 1989 Chad Rodent Control Research Project was initiated in response to the irruptive rodent population outbreaks of 1986–87. Funding for this cooperative program of the DWRC, AID/N'Djamena, and Chadian Ministry of Agriculture/Crop Protection Service was provided by AID's Africa Emergency Locust/Grasshopper Assistance Project. Objectives of the Chad project include (1) developing safe, economical, effective, and acceptable rodent control measures to protect crop production and improve food security in the Sahelian region, and (2) providing training and guidelines to the Chadian Ministry of Agriculture for long-term rodent population monitoring and control. Population monitoring has shown that Sahelian rodent species are extremely sensitive to both drought and rainfall conditions. These species cease to breed during droughts but respond to sufficient rainfall with high breeding activity and increased survival of young.



DWRC wildlife biologists were in Chad during August and September 1992 preparing budgetary and administrative details in agreement with AID/N'Djamena. Biologists also presented a 5-day workshop in rodent research and control in N'Djamena to 15 Chadian participants. In addition, Center wildlife biologists carried out laboratory toxicity studies of rodenticides on multimammate rats and unstriped grass rats. Rodent populations were normal in late 1989, dropped to extreme lows during all of 1990, and only began to breed and increase in response to normal rains during July 1991. Monitoring results during August 1992 indicate that rodent populations are increasing. DWRC consultancies continued through December 31, 1992, when intensive involvement in Chad ended.

Pakistan—Funding for DWRC's AID-funded vertebrate pest management project in Pakistan officially ended on June 30, 1991. Since the Pakistan project's initiation in 1985, DWRC provided or organized 14 short-term technical assistance, training, and project-planning consultancies. The project can claim many notable achievements. It has strengthened research and operational vertebrate pest-management programs within the Government of Pakistan; developed and implemented a control strategy to protect wheat and rice from rodent damage; transferred a developed rodent-control technology to farmers in the Gujrat wheat- and rice-growing area; advanced new knowledge on the biology and behavior of wild boar in Pakistan agriculture and implemented studies to evaluate methods to control wild boar; established a vertebrate pest research program at the University of Faisalabad, from which 44 Pakistanis have received postgraduate degrees; provided vertebrate pest-management training directly to more than 1,300 persons from the public and private sectors; and prepared and produced 28 technical reports, 6 information brochures, a training manual, 15 published articles, and numerous training aids, both written and audiovisual.

DWRC consulted in Pakistan during May 1992 to evaluate current and future research, training, and technology transfer programs of the Vertebrate Pest Control Project at the National Agricultural Research Centre. The project was functioning effectively, having submitted a 3-year research work plan with budget to AID and published or submitted 11 research articles. DWRC is pursuing ways to continue collaborative research and training activities with project personnel on a short-term basis.

Morocco—During the 1986–90 irruption of desert locusts in Africa, more than 4.5 million ha were treated with insecticides in Morocco. Insecticides are capable of killing most arthropods, thereby disrupting the community ecology of invertebrates and vertebrates on treated areas. Several organophosphate insecticides are capable of causing mortality in birds. The ecotoxicological risk of pesticide use in arid regions is virtually unknown. Because most knowledge on the hazard of insecticides has been developed in more temperate climatic zones, detailed field assessments are needed to ascertain the impact of insecticides in arid regions where locust control is undertaken.

In April 1990, DWRC began a cooperative project with AID/Rabat and the Moroccan Ministry of Agriculture's Plant Protection Department for research and training of Moroccan scientists to evaluate the impact of locust-control pesticides on the environment and nontarget wildlife. The project included two phases: (1) training Moroccan scientists in the concepts and methods of ecotoxicological studies, and (2) conducting studies to assess environmental effects of malathion and dichlorvos, the two principal insecticides that had been used in Morocco's locust-control campaigns.

Between May 1990 and October 1991, DWRC conducted six training sessions for Moroccan participants in ecotoxicological methods, methods of collecting animal and plant tissues for measurement of pesticide residues, chemical methods of residue measurement, statistical techniques, radiotelemetry, and field methods for determining the relative abundance of birds, mammals, and beneficial insects.

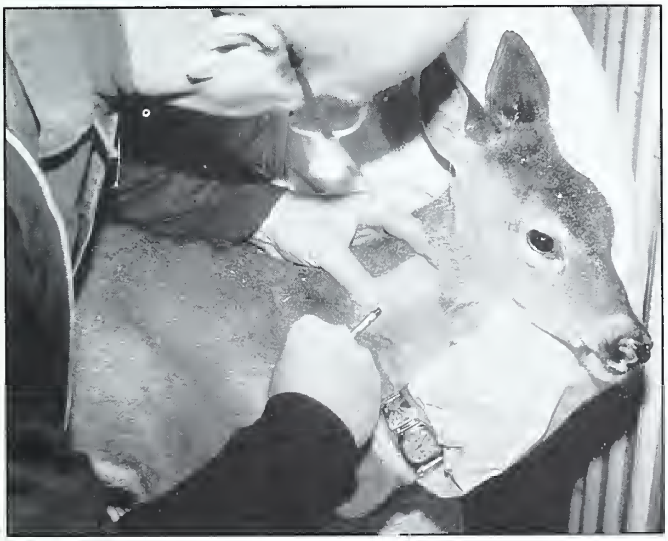
During January and February 1992, U.S. scientists from the DWRC, EPA, APHIS ADC operations, and Iowa State University joined teams of Moroccan scientists, contributing an impressive array of talent to conduct research on experimental plots in southern Morocco. At one time almost 70 individuals were in camp evaluating the effects of malathion and dichlorvos on birds, mammals, and insects. Poor application of insecticides compromised assessment of treatment effects. Nonetheless, studies were successful in providing training and experience in ecotoxicological research, which was a primary objective of the project.

The Brown Tree Snake in Guam—The brown tree snake, inadvertently introduced into Guam several decades ago, has overrun the island, endangering bird species and causing numerous power outages by short-circuiting power lines. DWRC was involved in studies of the brown tree snake in Guam under the terms of an interagency agreement between the Center and the U.S. Department of the Interior/Fish and Wildlife Service/ National Ecology Research Center. Research was designed to develop methods to control snake populations in Guam and to prevent the brown tree snake from dispersing to other Pacific islands. During September and October 1991, DWRC scientists helped conduct tests in Guam using methyl bromide, which was found to be effective as a fumigant against snakes in nonfood cargo situations. Fumigation of cargo that has a high risk of harboring snakes is one potential method for preventing their dispersal to other Pacific islands, including Hawaii.

Contraceptive Research

Control of reproduction may be a viable alternative to current wildlife damage control methods. Recent advancements in immunology present an opportunity to develop immunocontraception technology for nonlethal regulation of wildlife populations. DWRC has begun development on an immunocontraceptive vaccine plus delivery system that may be applied to effectively resolve management problems caused by overpopulation of damaging wildlife species. Emphasis in 1992 was on developing and testing efficacy of genetically engineered vaccines and oral delivery systems for white-tailed deer and wild Norway rats.

Deer Research—An immunization study was initiated in August 1992 by DWRC scientists and cooperators from Baylor College of Medicine and The Pennsylvania State University to obtain baseline information for developing a practical and cost-effective genetically engineered vaccine for controlling fertility in white-tailed deer. The study involves measuring immune, hormonal, and natality responses of 32 fertile does to natural porcine zona pellucida (PZP) and two rabbit recombinant antigens (RZP1 and RZP2). The antigens control fertility by immunizing females against their own eggs, thereby blocking conception by preventing sperm penetration. PZP is being used as a reference antigen because it has been successfully used to inhibit fertility in several wildlife species, including deer. Does were given booster injections on August 24 and on September 23, 1992. Blood samples were drawn on September 23 and October 7 to measure antibody titers and reproductive hormone levels, and also to perform deer in vitro fertilization tests. All does were exposed to bucks beginning October 19. In the spring of 1993, doe fawning will be correlated with antibody titers, hormone levels, and in vitro fertilization data to assess the effectiveness of ZP antigens.



Norway Rat Research—An immunocontraception study is under way to compare the effectiveness of two potential methods of rat immunocontraception. The study involves measuring the immune, hormonal, and natality response of 120 wild rats to either of two candidate immunocontraceptive vaccines. One method utilizes a mouse synthetic zona pellucida (ZP) antigen. The second method utilizes gonadotrophin-releasing hormone (GnRH). Preliminary results indicate that both methods of contraception are effective but that the GnRH method is decidedly more effective.

A continuation of this study in FY 1993 will include (1) boosting ZP-injected rats with a larger dose of vaccine to determine if total sterility can be achieved by this method, (2) monitoring hormone levels of GnRH-immunized males and females to determine length of sterility, and (3) initiating research to develop an oral vaccine delivery system for either or both of the vaccines.

Oral Delivery Systems—DWRC scientists initiated a study to determine the effectiveness of biodegradable microspheres to deliver an immunocontraceptive vaccine to the laboratory rat immune system via the Payer's patches in the small intestine. If this technique proves feasible, it may be used for oral immunization of wild rodents. Plans were also formulated to investigate the feasibility of two other vaccine carriers for oral immunization: live attenuated recombinant bacteria for genetically engineered vaccines and liposome encapsulation of vaccines to ensure their delivery to the immune system via the Payer's patches.

Development of Markers—A marker may be necessary for determining the consumption of vaccines or immunocontraceptive agents by white-tailed deer under field conditions. Studies using iophenoxic acid as an oral marking agent in deer were conducted in cooperation with Samuel B. Linhart at the University of Georgia in Athens. The total iodine in 10 blood sera samples taken from untreated deer ranged from 8.9 to 22 g/100 mL. Six days after each of 3 deer were treated with 1 or 5 mg of the acid per kilogram of body weight, the sera iodine values were 87 to 210 and 410 to 630 g/100 mL, respectively. Liver and muscle samples were obtained from untreated and acid-treated deer, and extraction procedures will be evaluated for measuring iophenoxic acid from tissues. It appears to be an effective blood marker.

Registration and Reregistration of Pesticides

Registration of APHIS/ADC Pesticide Products

The ADC program currently supports 23 Federal registrations, 42 State registrations, and 3 Emergency/Crisis Exemptions using a total of 10 pesticides. All of these pesticides and products must meet EPA data requirements. DWRC provided 50 data submission volumes to the registration division of EPA to support the following products during FY 1992.

Reregistration of APHIS/ADC Pesticide Products

APHIS/ADC currently maintains the registrations of eight pesticides as active ingredients that are used in APHIS/ADC end-use products. All of the technical and some end-use products are now undergoing reregistration by the EPA. DWRC has been providing information, technical support in negotiations, and data to EPA in support of the reregistration process for the last 3 years. DWRC submitted 35 data submission volumes to the Special Review and Reregistration Division of EPA for reregistration of ADC technical products during FY 1992.

Coordination of APHIS-Supported Consortia

APHIS/ADC coordinates three separate data-gathering consortia regarding zinc phosphide, strychnine, and DRC-1339. Responsibility for coordination has been given to DWRC, which organizes and maintains the consortia, evaluates data requirements, responds to all EPA requirements and regulatory notices, and facilitates the generation of data for the consortia.

Status of Current ADC Pesticides

PA-14 (Tergitol® 15S-9) Reregistration—PA-14 is a surfactant that is used as a blackbird roost toxicant in the Southeastern United States. APHIS received a reregistration data call-in for PA-14 on June 25, 1992. The data call-in was very extensive, and we estimated that the cost of required studies was at least $1.1 million and possibly up to $3.2 million. ADC determined that the reregistration costs for this product were beyond what the program could support. Therefore, the registration of PA-14 was voluntarily canceled as of September 25, l992.

Compound 1080 Registration—Compound 1080 is an acutely toxic mammalian predacide. All the data required for the conditional registration of Compound 1080 Technical (LPC) were completed and submitted to EPA. This conditional registration allows ranchers to continue to use the livestock protection collar in all of the States where it is registered. Because all rodenticide registrations for compound 1080 were canceled by EPA, the livestock protection collar is the only remaining registered use of this pesticide.

DWRC's Logan, UT, field station completed its tests of a larger collar that contains the same amount of compound 1080 but fits larger sheep and goats. These collars were effective against predating coyotes, and the efficacy data were submitted to EPA in 1992 with a request to revise the current registration to include the larger collar.

DRC-1339—DRC-1339 is a selective, slow-acting avian toxicant. DWRC continued its efforts to obtain Federal (Section 3) registrations for four uses that would allow many State (24c) registrations to be canceled and allow nationwide use: (1) All data requirements were met to revise the current *DRC-1339 Concentrate—Feedlots* registration. No additional data requirements are anticipated. (2) All data requirements were met to obtain a conditional registration for *DRC-1339 Concentrate—Pigeons*. As a condition of the registration, DWRC has to gather additional data over the next 2 years on the performance of baits with active ingredients at 0.25 and 0.37 percent throughout the United States. (3) Additional data were submitted to EPA to allow the continued processing of the *DRC-1339 Concentrate—Staging Area* registration application. DWRC submitted four studies to EPA and has been working with the Technical and Scientific Services staff of APHIS to draft label claims for the ADC program that are also acceptable to EPA staff. DWRC is developing a response to EPA's latest letter concerning proposed label claims. (4) APHIS submitted an application to EPA in 1990 for a *DRC-1339 Concentrate—Livestock Depredations* registration. This registration would allow nationwide use of DRC-1339-treated eggs to control raven or crow predations of newborn livestock, eggs of waterfowl, and the eggs or young of endangered species. In a review of that submission, EPA requested that APHIS redefine the LD_{50} of DRC-1339 in ravens (or determine a similar toxicity index) and determine the optimum effective field dose for DRC-1339 in eggs used as baits to control ravens.

In FY 1991, the first of these studies determined that the approximate lethal dose of DRC-1339 to ravens was 2.6 mg/kg, a fivefold decrease from the previously accepted value of 13.3 mg/kg. In FY 1992, a second study was conducted. Results showed the lowest effective dose of DRC-1339 in eggs was 2.6 mg/egg. Based on varying field conditions that could be encountered during use of DRC-1339 in eggs, a recommended dose of 10 mg/egg will be submitted to EPA for registration. This level is also consistent with the most effective dose for crow control. The 10-mg level is a tenfold reduction from that previously used in most 24c labels for raven control.

Residue data gathered in conjunction with these studies indicate that the potential for secondary hazard of DRC-1339 to nontarget organisms is almost nonexistent. Residues in ravens that die from ingesting DRC-1339 are no greater than 0.2 p/m.

Reregistration Efforts by the Starlicide® Consortium— Reregistration data requirements are being met through a consortium between APHIS and Purina Mills, Inc. DWRC has been cooperating with Purina Mills since 1990 to reregister DRC-1339 (Starlicide Technical) because the amount of DRC-1339 sold by Purina Mills does not warrant a large expenditure of funds by Purina Mills or APHIS/ADC. DWRC negotiations and waiver requests resulted in the reduction of data requirements estimated to cost more than $1.1 million as originally specified by EPA in the Starlicide data call-in. Purina Mills has completed 21 product chemistry data requirements and 3 of the requirements for environmental fate and residue chemistry for Starlicide and submitted them to EPA. DWRC has completed 14 studies on wildlife and aquatic toxicology, human and domestic animal toxicology, and environmental fate of Starlicide and has submitted them to EPA through Purina Mills. Six studies remain to be completed and are currently being performed by DWRC under contracts to private laboratories. These include two wildlife toxicology studies and four environmental fate studies.

Avian Oral Toxicity—To meet EPA reregistration data requirements, two studies on DRC-1339 8-day acute dietary LC_{50} range-finding in 11-day-old bobwhite quail and 10-day-old mallard ducklings were contracted to an outside laboratory. The objective of these studies is to assess the toxicity of DRC-1339 so concentration levels can be established for later definitive studies. Test diets for each species were 0, 10, and 100 p/m. There was 100-percent mortality in the quail at 100 p/m; this was the only test level that produced mortality. Definitive test protocols with diets of 0, 9.75, 39, 78, and 156 p/m for quail, and with diets of 156, 312, 625, 1,250, 2,500, and 5,000 p/m for ducks have been developed. Analytical chemistry support for these studies is being provided by a second contract laboratory.

Environmental Fate Studies—A phase 4 data call-in was received in the spring of 1992 for DRC-1339 that requested additional studies. A private-sector research contract was recently awarded to conduct four environmental fate studies using ^{14}C-DRC-1339. This research will involve aerobic soil biodegradation, soil sorption/desorption (including leaching of metabolites in "aged" soils), aqueous photolysis, and fish bioaccumulation studies. DWRC personnel are monitoring these studies and serving as scientific advisors.

Gas Cartridge—The gas cartridge contains carbon and sodium nitrate and is used as a den and burrow fumigant for rodents and predators. Several efficacy studies were submitted to EPA to support the proposed new *Gas Cartridge II* for rodents and the existing *Gas Cartridge for Coyote Control*. Studies were completed during 1992, at the request of the ADC program, to evaluate the efficacy of the coyote cartridge on skunk, badger, and fox for possible addition to the coyote label. These studies showed that the cartridge was effective for fox and skunks but not for badgers. Amending the coyote label will allow all existing State registrations to be canceled.

The Gas Cartridge II rodent cartridge (with only two active ingredients) is designed to replace the current Gas Cartridge that contains carbon, sodium nitrate, phosphorus, and sulfur. DWRC also provided the Technical and Scientific Services staff with information and statements that can be added to existing labeling to reduce the possible impact of these fumigants on nontarget species.

Skunk Efficacy Study—In October and November 1991, efficacy data were obtained for control of the striped skunk. The gas cartridge is a pyrofumigant with two active ingredients (sodium nitrate and charcoal) that produces high concentrations of carbon monoxide when burned. This study was requested by 17 ADC State Directors to support a label amendment to include the striped skunk. To add skunks to the label, EPA required a field efficacy investigation demonstrating at least 70-percent mortality when the cartridge is used in dens to control skunks.

The area known as the Shoshone River Basin in northwestern Wyoming was selected for study because an outbreak of rabies in striped skunks had recently occurred in Park and Bighorn counties and because an ADC control program was already in place. Twenty-two striped skunks (10 adults and 12 juveniles) were live-trapped and equipped with radiocollars. Use of 1 gas cartridge in denning situations caused 100-percent mortality for 14 striped skunks, including 6 radio-equipped animals and 4 cohabitants found upon excavation of dens, and 4 additional striped skunks that were held overnight in a shelter during a blizzard, released in accessible known skunk dens, and fumigated 1 hour after release. The remaining radio-equipped striped skunks were not included in the study because contact was lost with 7, 3 did not use dens, 1 died of rabies, and 1 wore a collar that put out a very intermittent signal. Death was confirmed by excavation. No nontarget species were found during carcass retrieval. Active striped-skunk den systems had one entrance/exit. Some skunks also utilized abandoned coyote dens when the temperatures were near or below zero.

Fox Efficacy Study—In May 1992, efficacy investigations of den mortality were conducted for the red fox in Moffat County, northwestern Colorado, using the gas cartridge. Thirty-two ADC State Directors had requested that DWRC provide these data to support a label amendment to include the red fox on the coyote gas cartridge registration. DWRC research investigators collaborated with numerous ADC personnel from Colorado to collect the data. The area known as "the Great Divide" was selected because ranchers incur high losses of lambs during the red-fox denning season. Nine red fox were lived-trapped and equipped with radio collars. Placement of a single, lit gas cartridge into 8 dens produced 100-percent mortality for 8 radio-equipped animals and 2 cohabitants found upon excavation. The 100-percent efficacy exceeded the 70-percent minimum standard established by EPA. All active red-fox den sites had animal parts nearby or within the den system, including lambs, mountain cottontails, and sage grouse. No nontarget species killed by fumigation were found during carcass retrieval.

New Formulation for Gas Cartridge—Evaluations were initiated in cooperation with Pocatello Supply Depot personnel to develop a two-active-ingredient gas cartridge formulation that will not spill out when the gas cartridge is burned in a vertical position with the fuse end down. Preliminary results indicate that water could be an effective replacement for mineral oil in the Gas Cartridge II formulation, which contains sodium nitrate and charcoal (active ingredients) as well as fuller's earth and borax (inactive ingredients). When the optimum formulation is determined, fuse and cartridge burn-time tests will be conducted to satisfy EPA safety requirements.

All of the reregistration data requirements for the two technical ingredients of the gas cartridge have been completed by DWRC, and EPA has issued Reregistration Eligibility Documents (RED's) for both active ingredients. DWRC data were extensively cited in the sodium nitrate RED. DWRC negotiations and waiver requests resulted in the waiving of all carbon data requirements and most requirements for sodium nitrate. The RED's also included data call-ins for each of the APHIS/ADC gas cartridges produced by the Pocatello Supply Depot. DWRC requests resulted in EPA's waiving all toxicology data requirements for both gas cartridges.

Strychnine Alkaloid—Strychnine alkaloid is an acutely toxic rodenticide used on milo and oat baits for control of field rodents. Data were submitted to EPA to support an ADC request to drop the registrations of 0.35-percent strychnine milo and 0.35-percent strychnine milo for hand baiting pocket gophers and replace them with 0.5-percent milo baits. This effort was required by the Strychnine Settlement Agreement and consisted of the preparation of eight volumes of data for each registration. If EPA accepts these data, all ADC strychnine baits will be 0.5 percent. DWRC also submitted additional data to establish the nominal pesticide claims and allow for the removal of yellow dye from each of these formulations. The yellow dye was originally required to reduce hazards of the strychnine baits to birds; however, current use is below ground, where the yellow dye is not necessary for reducing consumption by nontarget species.

DWRC has submitted several studies required to demonstrate the efficacy of ADC's end-use products for pocket gopher control. These data submissions have been used by members of the Strychnine Consortium and by ADC to maintain belowground end-use product registrations for 0.5-percent strychnine S.R.O. and 0.5-percent strychnine S.R.O. for hand baiting pocket gophers.

All aboveground uses of strychnine are currently prohibited by a U.S. District Court injunction based on the potential hazards of strychnine to endangered species. Before any aboveground use of strychnine can be reinstated, EPA must confer with the U.S. Department of the Interior's Fish and Wildlife Service to determine whether label statements can be developed that will reduce incidental take and preclude possible jeopardy to endangered species. The District Court will have to be convinced that such label statements are appropriate and sufficient. ADC and the Strychnine Consortium have received correspondence from EPA indicating the willingness of EPA to work with the consortium to develop the appropriate label language.

Reregistration Efforts by the Strychnine Consortium—DWRC has been coordinating the Strychnine Consortium since l989. The consortium, which has 26 members, raised funds for generation of data required by the Strychnine Settlement Agreement by assessing a fee for each member and by placing a surcharge on sales of the technical product. During the last 3 years, on behalf of the consortium, DWRC has submitted 33 studies to EPA in support of the strychnine technical reregistration. These studies were either conducted at DWRC or contracted to private laboratories and monitored by DWRC staff.

Environmental Fate Studies—Three environmental fate studies are required for the reregistration of strychnine alkaloid. The following progress on those studies was made during FY 1992:

A final report for the *aerobic soil metabolism study* was submitted to EPA during March 1992. Nonradio-labeled strychnine, when applied to a sandy loam soil at a concentration of 100 p/m, was found to degrade in an erratic manner during a 2-month incubation period. Chromatographic signals of significant magnitude that could be attributed to strychnine degradation products, using high-performance liquid chromatography with ultraviolet detector, were not observed. There were no long-term toxic effects of the chemical observed on the population growth of soil bacteria, actinomycetes, or fungi. In view of these initial biodegradation results, a supplemental study will be conducted. This research will involve two concentrations of strychnine (1 and 10 p/m), a modified soil-incubation procedure, and possibly use of both alternate soil extraction procedures and analytical instrumentation.

A *strychnine sorption study* was completed during FY 1992, with a final report submitted to EPA in June. The sorptive capacities of four soils that varied in texture from a coarse loamy sand to a heavier sandy clay loam were evaluated in the laboratory using batch equilibrium methodology. The study results, together with data obtained during a preliminary research phase, indicate that strychnine is rapidly absorbed to soil colloids and held in a tenacious manner to soils that vary in pH, organic matter, and clay content. These data suggest that in field applications, strychnine will be relatively immobile in soils and should not be of environmental concern from the standpoint of plant translocation or contamination of surface water or ground water.

A study of *photodegradation in soil* was previously submitted to EPA; however, EPA requested additional studies to clarify some unexpected results.

Avian Reproduction—Using Strychnine Consortium funds, DWRC contracted with a private-sector firm to conduct two concurrent, 26-week, reproductive toxicity studies involving mallard ducks and bobwhite quail. DWRC personnel monitored the biological portion of the study. Analyses for uniformity of the weekly diets (mixes of strychnine alkaloid and Purina Game Bird Breeder Layena®) fed to the ducks and quail during these studies were performed by the analytical chemistry section at DWRC. The studies were completed between January and July 1992; during this time, 4 groups of ducks were fed 0, 35, 70, and 140 p/m diets, and 4 groups of quail were fed 0, 300, 600, and 1,200 p/m diets ad libitum. The large difference in toxicity of strychnine to the two species is an unusual finding discovered in earlier pilot research. Low egg production was noted for the mallards fed 140 p/m; whereas, normal egg production (81 percent) and hatchability (93 percent) were observed for the quail fed the highest concentration diet (1,200 p/m). Obviously, the two species display different reproductive tolerances to strychnine, with waterfowl showing sensitivity and upland birds, insensitivity.

Zinc Phosphide—Zinc phosphide is an acutely toxic rodenticide used to control commensal and field rodents. Data were submitted to EPA to allow ADC to remove the yellow dye incorporated into zinc phosphide on wheat for mouse control. The yellow dye was originally required to reduce hazards of the baits to birds; however, it proved ineffective in reducing consumption by nontarget species because the yellow color is overwhelmed by zinc phosphide's grey-black color, which is a better bird deterrent than yellow.

Reregistration Efforts by the Zinc Phosphide Consortium—The Zinc Phosphide Consortium, with 17 members, was formed in April 1991 to generate funds to meet data requirements imposed by the February 1991 data call-in for the reregistration of technical zinc phosphide. Funding is being generated by a one-time assessment on each consortium member and by a surcharge placed on all technical zinc phosphide ordered from technical registrants in the United States. These registrants are the only source for zinc phosphide in this country. DWRC is coordinating the consortium, corresponding with EPA and contracting for studies. On behalf of the consortium, DWRC negotiates data requirements and prepares data waivers for EPA consideration.

Thus far, negotiations with EPA on behalf of the consortium have resulted in the reduction of over $3.5 million worth of data requirements from those specified in the data call-in. EPA is still considering an additional reduction of $2 million worth of studies. The consortium has agreed to submit six studies to EPA at a cost of over $500,000: a 90-day rodent feeding study, three mutagenicity studies, a rat teratogenicity study, and a terrestrial field study. The Consortium is directly funding two studies, and the California Department of Food and Agriculture (a consortium member) is funding four studies. DWRC has also analyzed the technical product for purity and impurities, helped the consortium contract for a nontarget literature review of zinc phosphide use, and performed studies to define a test substance for the consortium's use that will cover all of the technical products.

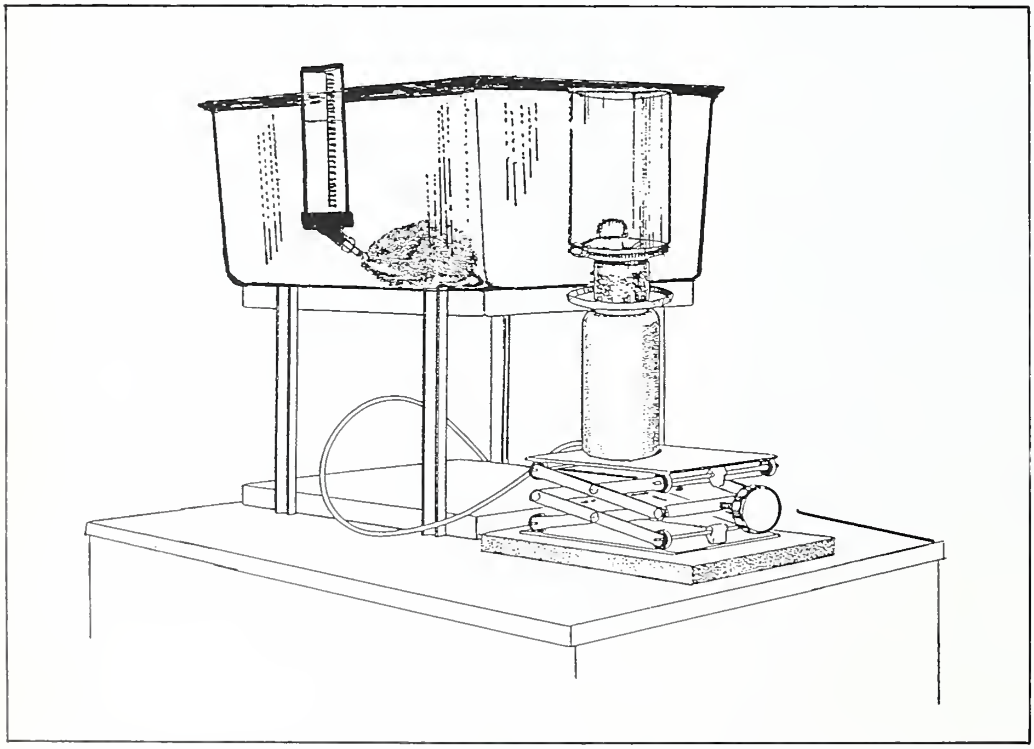
Vole Carcass Residues—As part of a requirement by EPA for submission of a study delineating the carcass residues of zinc phosphide in voles, a study is being conducted to present prairie voles with a steam-rolled oat bait containing 2 percent zinc phosphide and then analyze the carcasses for residual zinc phosphide.

An automatic food-intake measurement system, comprised of a computer and four digital balances, was purchased to monitor the minute-by-minute food consumption of rodents in laboratory studies. Between June and August 1992, DWRC investigators conducted a pilot study to measure prairie vole consumption patterns of steam-rolled oat bait with 2-percent Alcolec-S using the device. This research allowed troubleshooting of the automated system plus collection of additional prairie vole food, water, and body weight data during laboratory feeding trials. Twelve voles weighing between 35 and 50 g ingested an average of 2.4 g of the bait per day. These figures confirmed initial research conducted with prairie voles in 1991, which demonstrated that although ingestion of oats containing 2-percent zinc phosphide was significantly lower than ingestion of unadulterated oats, ingestion of a mean of 0.24 g of oats treated with 2-percent zinc phosphide was lethal to this species.

Vulnerability of Red-Winged Blackbirds and House Sparrows to a CPT Aerosol—Limited research was conducted on CPT, a potential blackbird roost toxicant. Research in FY 1992 assessed the potential hazards to nontarget species posed by the use of CPT. DWRC investigators completed a study designed to assess the vulnerability of red-winged blackbirds and house sparrows (a nontarget species) to a 5-minute whole-body exposure of respirable CPT. Mortality in both species was compared to the response of the starling, a species very sensitive to CPT. When dosed orally, the red-winged blackbird is a CPT-sensitive species and the house sparrow is not. In all, 150 birds were involved in the comparison.

Preliminary data analysis clearly indicates that mortality is much greater for starlings and red-winged blackbirds than for sparrows and that responses of the three species to respirable CPT are in the same proportion as indicated by the oral data.

The results indicate that a respirable CPT aerosol used to control pest species of roosting birds sensitive to CPT would not increase the hazard to nonsensitive avian species. DWRC scientists are developing a red-winged blackbird mortality-prediction model, based on blood samples drawn to generate blood chemistry values as predictors.



This cage is designed to monitor continuous bait intake by meadow voles during a DWRC study of whole-body zinc phosphide residues.

Information and Technology Transfer

Technology Transfer

The Information and Technology Transfer Project (ITT) expanded its functions and services in FY 1991–92. Project staff planned and coordinated the DWRC Expert Panel Meeting in March 1992. Experts in wildlife damage control from across the United States gathered to brainstorm and exchange ideas on how best to develop new control techniques and prioritize research areas in accordance with perceived needs of APHIS' ADC program. Plans are now under way for a Denver-based international symposium on contraception in wildlife management in October 1993. ITT has also been working with APHIS personnel to produce a new Center informational videotape, brochure, and other outreach materials. Numerous tours and presentations were given to Center visitors. The annual publication list for 1991 was completed, and the quarterly DWRC Research Update has been redesigned.

Library

The DWRC Library has been used extensively as an information source for ADC personnel involved in updating "The Prevention and Control of Wildlife Damage," published by the Great Plains Agricultural Council. ADC field personnel have also requested information on fencing, night lighting, wolf predation, lead shot, ravens, bears, and many other topics to aid them in their daily jobs. Assistance was provided through our international programs section to vertebrate pest management personnel in other countries. The staff has also been working with U.S. Fish and Wildlife personnel stationed at the Rocky Mountain Arsenal. The arsenal was recently designated a national wildlife refuge, and numerous studies on various fauna and pesticides are ongoing at the site.

Online searching of relevant literature is necessary to write protocols and initiate Good Laboratory Practices studies. The library has also provided information for personnel involved in contracting, hazardous waste disposal, patent application, statistics, purchasing, and management.

DWRC library personnel completed a subject index to the "Vertebrate Pest Conference Proceedings" (nos. 1–15) that will be published in 1994.

A new CD-ROM data base, Wildlife Worldwide, has been added to the collection to replace Wildlife and Fisheries Review. The new data base incorporates Wildlife Review citations, Biological Documentation Center of the National University of Costa Rica (BIODOC) materials, and citations from the Hierarchical Environmental Retrieval for Management and Engineering (HERMAN) data base. The library now has the capability of accessing the Colorado Alliance of Research Libraries (CARL) data base and can search holdings in numerous libraries throughout the West electronically. Online search capabilities include over 400 Dialog data bases, Scientific and Technical Information Network® (STN International) chemical data bases, Chemical Information Systems data bases, and access to the National Pesticide Information Retrieval System (NPIRS). Library personnel completed more than 450 searches in FY 1991–92 in support of ADC operations and research programs.

Staffers also integrated bibliographic citations from online searches with citations from various inhouse collections to compile specialized data bases on zinc phosphide, strychnine, and DRC-1339. Library personnel have chosen Procite™, a personal bibliographic data-base software package, as a standard for use by Center staff. The librarian has encouraged all personnel to purchase this product and is providing ongoing training. The library staff has compiled specialized Procite data bases on the brown tree snake and immunocontraception. More than 200 citations have been added to the inhouse predator data base.

A collection development policy for the DWRC Library has been written. Nearly 2,000 items have been ordered through interlibrary loan, and more than 500 items were lent by DWRC to other libraries. More than 2,500 reprints of articles by DWRC authors have been mailed to interested parties. Searching the library collection is now available to staff through an online catalog system.

Archives

The archives unit of ITT was an active participant in the weeklong EPA audit of several Good Laboratory Practices studies completed by Center personnel. This unit also logged in, checked, and verified the completeness of 56 studies. Archives personnel developed a new archive system for miscellaneous research materials, scanned all strychnine documents into the optical storage system, and set up new data bases for pesticide consortia documents. The optical storage system equipment was itself upgraded. Archives staff now participate in actual auditing of data in conjunction with DWRC's quality assurance officer.

Outreach Activities

Work at the Monell Chemical Senses Center

Scientists from DWRC's Monell Chemical Senses Center station are collaborating with New Jersey APHIS ADC personnel and the New Jersey Farm Bureau to test the goose-repellent properties of white flags, black flags, and Mylar™ streamers in a large-scale field/trial demonstration project. Farmers throughout southern and coastal New Jersey are requesting information about trial results.

Monell scientists are collaborating with chemical companies across the United States and abroad to develop new bird repellants for agricultural and industrial uses. As registrations are imminent, grower groups are now becoming participants in these efforts.

Monell investigators are also collaborating with horticulturalists from the State Arboretum of Pennsylvania to evaluate various commercial and experimental deer repellants. A brochure describing trial results will be prepared for distribution to residents of the Delaware Valley and the New York metropolitan area.

The Florida Field Station

Michael Avery, project leader of the Florida field station, presented a seminar at the University of Florida entitled "Animal Welfare Concerns in Wildlife Research." This presentation was part of an animal rights/animal welfare seminar series sponsored by the University Veterinarian's office. Avery's presentation on the use of wild birds as experimental subjects focused on research activities and animal care procedures at the Florida field station.

As part of an ongoing cooperative research and training relationship between the station and the University of Florida, personnel at the field station assisted in teaching the zoology department's advanced ornithology class. At the field station, students received an introduction to DWRC's Florida research activities, and then they participated in practical exercises on the capture and safe handling of wild birds.

Ellis Greiner, of the University of Florida College of Veterinary Medicine, and Terry Norton, of the Riverbank Zoo in Columbia, SC, visited the Gainesville station to discuss possible collaboration on a study relating to the Bali mynah, one of the world's most endangered bird species. Norton directs a program to breed the mynah in captivity, but the program's success has been limited due to an unusual liver parasite that kills recently fledged captive-raised birds. Greiner and Norton hope to develop means to combat the infectious disease using the starling, which is closely related to the mynah, as a model species.

DWRC's Kristin Brugger presented a talk on bioenergetics and animal damage assessment for the International Vertebrate Pest Management Course at Bowling Green State University.

The Hawaii Field Station

Biologist Mark Tobin presented a seminar on rat control research at the International Rice Research Institute meeting in the Philippines during July 1992. Other Hawaii field station personnel have participated in meetings held by the Hawaiian Sugar Technologists, the Hawaiian Macadamia Nut Association, and various other organizations to provide information on rat control research to farm managers and field workers.

The Mississippi Field Station

James Glahn worked with the Nebraska Extension Service (University of Nebraska) in the development of a nationwide extension leaflet on controlling starling damage to agriculture. Glahn consulted with the Texas Citrus Mutual Association and provided technical guidance for developing initiatives to reduce great-tailed grackle damage to citrus.

The North Dakota Field Station

George Linz attended SIGCO Days, in Jamestown, ND. This annual event provides an opportunity for sunflower growers to learn about new research designed to increase sunflower production. Linz presented information to growers on using Rodeo herbicide to alter blackbird roost sites located in dense cattail marshes. This technique is aimed at dispersing blackbird populations concentrated in these roosts and, thus, reducing sunflower damage in local areas. Linz also attended the Lake Region Extension Roundup in Devils Lake, ND, the Central North Dakota Oil Crop School in Carrington, and the 40th Nelson County Crop Improvement Association meeting in Tolna.

In 1992 Linz presented a seminar on cattail management using Rodeo herbicide to officials of the U.S. Fish and Wildlife Service, North Dakota Game and Fish Department, APHIS ADC, the National Sunflower Association, and the North Dakota governor's staff.

The Ohio Field Station

For the eighth year, personnel from DWRC's Ohio field station presented a program on wildlife ecology and interaction of bird populations with human activities to about 400 fourth- and sixth-grade children as part of a 2-day conservation/education field day sponsored by the Erie Soil and Water Conservation District. Also in cooperation with the district, Tom Seamans presented a talk on the integration of wildlife habitat management with woodlot timber management as part of a forestry field day.

Richard Dolbeer has been asked to serve on the 25-person Standing Committee on Applied Ornithology of the International Ornithological Congress. Applied ornithology, as defined by the committee, covers all methods of reducing harm to people from birds. One of the main tasks of the committee is to increase communication among scientists involved in the various fields of ornithology.

Dolbeer also presented a talk on bird and mammal damage control in sweet corn to 125 growers at the Ohio Fruit and Vegetable Growers Congress in Cleveland. He talked primarily about the use of bird-resistant cultivars, Mylar reflecting ribbons, and integrated pest management to control insect and bird damage.

The Utah Field Station

Fred Knowlton, wildlife biologist from DWRC's Logan, UT, field station, participated in a symposium on the biology and management of the eastern coyote, sponsored by the University of New Brunswick at Fredericton. He discussed population aspects associated with two long-term field studies of predator–prey interactions.

Knowlton also made a presentation to the staff and invited guests at the USDA Jornada Experimental Range near Las Cruces, NM. The discussion covered coyote biology, behavior, population mechanics, and depredation control technologies. He described the Logan station's coyote research program to a joint meeting of the American Farm Bureau Association's Public Lands Advisory Committee and Sheep and Goat Advisory Committee held at Utah State University. Biologist Doris Zemlicka shared similar information with attendees at Utah Trappers Association's annual convention.

Each year personnel from the Logan station operate a recruiting table on behalf of APHIS at a job fair held on the campus of Utah State University. Dick Burns and Doris Zemlicka, the two biologists who staff the table, report that interest in various employment opportunities within the agency is very evident among students. Also at Utah State, DWRC biologists participated in the "Expanding Your Horizons" program to encourage high school women to consider academic endeavors in curricula involving sciences and mathematics.

Logan field station personnel cooperated with professional photographer Franz Camenzind, who has been obtaining film footage for a documentary on coyotes. The documentary is scheduled to be aired on public television's "Nature" series in 1993.

Visitors to our Millville, UT, predator research facility have included a variety of primary, secondary, and college classes, as well as scout groups. Each year, between 350 to 400 people have visited the facilities for tours of the coyote kennels and observation pen complexes, slide talks on various research projects, and the opportunity to discuss coyote biology, behavior, and management, as well as the maintenance and handling of captive coyotes.

The Washington Field Station

Personnel from our Olympia, WA, field station contracted with mentally and physically challenged high school students at Chehalis High School to construct devices for monitoring mountain beaver activity.

Biologists at the Olympia station presented forest animal research information to the Master Gardeners certification program and information about forest animal pesticides for pesticide recertification classes at Washington State University.

Dale Nolte, a biologist from the Olympia station, presented a seminar on forest damage and biology of the mountain beaver at the Forest Management and Marketing Field Day sponsored by Washington State.

Denver Headquarters

John Cummings participated in an outdoor wildlife education program for sixth-grade students. The program was organized by Jefferson County Public Schools, Golden, CO, to promote environmental awareness.

During a sabbatical with the Queensland University of Technology (QUT) in Brisbane, Australia, DWRC's Richard Engeman provided statistical consulting and training on wildlife damage issues ranging from rat damage in sugarcane to overgrazing by wallabies on an island along the Australian coast. He also served as an external thesis examiner for a Ph.D. dissertation. Further exchanges with Australian animal damage researchers were promoted through this visit: two researchers from the Centre for Biological Population Management (QUT) and one from Queensland's Lands Protection Branch will visit DWRC and its field stations in 1993 to work with our researchers. Engeman also addressed the Maranoa Grazier's Association in Mitchell, Queensland, on the use of the livestock protection collar for reducing sheep losses to coyotes in the United States.

In addition to his Australian outreach work, Engeman has been involved in establishing collaborative relationships to conduct mutually beneficial animal damage research with the Institute for Nematology and Vertebrate Research in Münster, Germany, and with the University of Mexico in Mexico City.

Doreen McHugh, Clay Mitchell, Janelle Duke, Sella Smillie, and Peter Savarie cooperated with EPA in sponsoring a training seminar on standards for Good Laboratory Practices under the Federal Insecticide, Fungicide and Rodenticide Act. The audience included members of the APHIS Grasshopper Integrated Pest Management Project and personnel from Mycotech Corp.

Bruce Kimball and Doreen McHugh, of the analytical chemistry section, visited an innercity middle school in Denver to stimulate interest in scientific careers with the Government for minorities and women.

In cooperation with APHIS' Veterinary Services branch, DWRC's animal care section provided training in the care of captive wildlife to APHIS veterinarians and interns in the Denver area.

Phyllis Parker, a technologist in the animal care section, joined the USDA Departmental Occupational Immunization Committee. Her familiarity with cell culture and preventing the exposure of employees to pathogenic organisms via prophylactic immunization makes Parker an expert in this field.

Members of the animal care section also coordinated comments for consideration by the American Veterinary Medical Association's Panel on Euthanasia. The effort is intended to broaden the application, so as to encompass the diverse situations encountered by field personnel in ADC operations.

The animal care section hosted a meeting of the Mile-Hi chapter of American Association of Laboratory Animal Science. Those attending were provided a tour of the Denver Wildlife Research Center animal facilities by our animal care staff.

Ray Sterner, from our chemical development/registration section, participated in the Colorado Alliance for Science's "visiting scientist" program. He made classroom presentations to several fourth- to eighth-grade classes at local public schools, describing the scientific method and the diverse wildlife-research topics being addressed by DWRC.

Sterner also participated in APHIS' Summer Intern Program—a program designed to get students from underrepresented racial groups interested in science professions or careers with USDA. A minority student from Southern University and A&M College, Baton Rouge, LA, was hired during 1992 and received on-the-job experience in laboratory research, particularly the conduct of studies to determine bait-feeding patterns of prairie voles.

During the fall and spring semesters of 1991 and 1992, Sterner taught a three-credit course titled "Research Methods I" for the department of psychology at Metropolitan State College of Denver. He also consulted with numerous official visitors to DWRC, including Arvo Myllymaki, principal research scientist, Agricultural Research Center, Jokioinen, Finland; and Yousef Mian, scientific officer, Vertebrate Pest Control Center, Bangladesh Agricultural Research Institute, Joydebphur, Bangladesh.

Peter Savarie, research pharmacologist with the chemical development/ registration section, traveled to Chad for the international programs research section during October 1990 to assist the Chad Rodent Research Project with rodent research and training activities. He cooperated with Juan Spillett, project leader, and Mornan Kounade, project assistant, in developing a rodenticide toxicity lecture for a rodent research and control workshop held for technicians of the Chadian Ministry for Agriculture Crop Protection Service in November 1990.

Savarie also presented a talk on brown tree snake problems in Guam to the Arapaho Sertoma Club, Englewood, CO, in January 1992. He also provided technical guidance to personnel at the Southeastern Cooperative Wildlife Disease Study at the University of Georgia (Athens) for studies using iophenoxic acid as an oral marking agent in white-tailed deer. Technical assistance on the use of iophenoxic acid as a biomarker was also provided to scientists at the Forest Research Institute, Christchurch, New Zealand, and the Agriculture Protection Board of Western Australia. These scientists are evaluating the acid as an agent to identify animals and to quantify their bait consumption.

Bob Starr participated in a symposium on the regulation of agrochemicals in the 1990's, sponsored by the American Chemical Society. One topic of concern was EPA's current environmental fate guidelines, which were published in the 1980's but keyed to pesticides developed during the 1960's. This timelag may mean that the requirements of the guidelines are no longer pertinent. Although today's pesticides are being developed with reduced persistence and lower use rates, their greater mobility in soil and other environmental concerns are becoming critical issues.

Dan Thompson and Lowell Miller met with a broad variety of individuals and private groups, academic institutions, and governmental agencies concerning immunocontraceptive research. Some of these organizations include People for the Ethical Treatment of Animals, the Humane Society of the United States, the Englewood (CO) Sertoma Club, New Jersey's Department of Fish and Game, and the Armed Forces Pest Management Board.

Bob Phillips, research biologist in DWRC's predator control research section, attended the International Standards Organization's Working Group 3 meeting in Toronto in September 1992. This group is charged with developing humane standards for various types of mammal restraint devices. The meeting was attended by representatives from the United States, Canada, the United Kingdom, Sweden, and New Zealand. Following the working group meeting, the U.S. Technical Advisory Group (TAG) met to discuss formal comment on the draft trap standard. The TAG includes representatives from APHIS' ADC program, universities, State wildlife agencies, animal welfare interests, trap manufacturers, and national and State trapping organizations. Proposed trap standards are scheduled for presentation to the international community in the spring of 1994.

The same month, Bob Phillips and Guy Connolly attended a predator symposium held in Fort Stockton, TX, sponsored by the Texas Agricultural Extension Service. The purpose of the symposium was to enlighten resource managers, ranchers, and the general public about the biology and ecology of major predator species and their interactions with humans. Connolly spoke on coyote ecology in the Southwestern United States, and Phillips reported on the population ecology of eagles in North America.

International Programs Research Section

Scientists from the international programs research section participated in the International Course on Vertebrate Pest Management with Emphasis on Needs of Developing Countries, held at Bowling Green State University, Bowling Green, OH, in 1991. Twelve students from Africa, Asia, the Caribbean, and the United States attended these sessions.

International Visitors

The Center hosted numerous visiting scientists and administrators from developing countries during the past 2 years. In June 1992, Md. Emdadul Haque, from Bangladesh, and Lee Choon Hui, from Malaysia, visited DWRC as part of the Bowling Green State University vertebrate pest management course. Prior to visiting Denver, they spent 1 day at our Sandusky, OH, station.

Moroccan entomologist Said Ghaout, ornithologist Abderrahim El Hani, and mammalogist El Hassan Arroub visited DWRC between April and May 1992 to work with our staff in preparing a report of the cooperative research on insecticide impacts conducted in Morocco during January and February.

Other international visitors in 1992 included Shakunthala Sridhara, from the University of Agricultural Sciences, Bangalore, India, who visited DWRC in March to present a seminar and discuss research interests and ways in which our two organizations might be able to cooperate in future rodent research; Beatriz Villa, from the biological institute of Mexico's National University of Agriculture, and Donna Scott, former program assistant in the section who is currently employed at the American Embassy in La Paz, Bolivia.

Supporting Research Abroad

DWRC continued to provide guidance and support for international graduate students in vertebrate pest management. Sayed Ahmed, an International Rice Research Institute-sponsored doctoral student at Colorado State University, completed his research at DWRC and received his doctorate in the spring of 1991. His thesis was "Development of a Toxicant Delivery System Utilizing Rodent Grooming Behavior." Yousuf Mian, DWRC Project counterpart from the Bangladesh Agricultural Research Institute, continued advanced studies at Colorado State emphasizing statistics, modeling, and computer use in describing and evaluating vertebrate pest problems. Ejaz Ahmad, DWRC counterpart from the Pakistan Vertebrate Pest Control Project, entered Colorado State in the fall of 1991 as a Ph.D. candidate in the Department of Fishery and Wildlife Biology. His proposed research topic is the use of biodegradable microspheres as oral vaccine carriers for rodents. He also has written or been the coauthor of about 10 scientific publications and a training manual on vertebrate pest management.

Studies of zinc phosphide ecotoxicology in animals and the environment are being carried out by Shahid Munir, scientific officer at the Vertebrate Pest Control Laboratory at the National Agricultural Research Centre, Islamabad, Pakistan. (Munir spent 6 weeks at various DWRC locations in the United States during 1989 learning to measure the stability of rodenticides under different environmental conditions and evaluate their effects on nontarget animals.) He will continue his ecotoxicology studies in a Ph.D. program at the University of Punjab in Lahore, Pakistan.

The Center's Research and Support Staff

Birds

Avery, Michael L., Supervisory Wildlife Biologist (Research)—Development of nonlethal bird-management methods; investigations of avian feeding behavior, exotic species, and international crop damage problems.

Belant, Jerrold L., Wildlife Biologist (Research)—Research on bird–aircraft strikes and gull biology; chemical immobilization of animals; and biology of the common loon.

Brugger, Kristin E., Wildlife Biologist (Research)—Avian physiology and behavior, with particular emphasis on physiological adaptations and constraints that influence food choice of problem species.

Clark, Larry, Biologist (Research)—Discovery and development of vertebrate repellants and attractants using molecular modelling techniques for use in crop protection, bait formulations, and wildlife conservation.

Cummings, John L., Wildlife Biologist (Research)—Development of repellants for agricultural crops and grass to reduce damage caused by waterfowl, specifically Canada geese.

Dolbeer, Richard A., Wildlife Biologist (Research)—Population studies of vertebrate pest species, development of cultural techniques for reducing bird damage to agricultural crops, and studies of safety hazards caused by wildlife at airports.

Glahn, James F., Wildlife Biologist (Research)—Problem definition and control-methods development studies of winter roosting blackbirds and starlings and piscivorous birds in commercial aquaculture.

King, David T., Wildlife Biologist—Radio-telemetry studies with double-crested cormorants and problem definition studies of bird damage.

Mason, J. Russell, Research Psychologist—Development of vertebrate class-specific chemical repellants and biologically based chemical attractants for birds and rodents.

Mott, Donald F., Supervisory Wildlife Biologist—Problem definition and control-methods development studies of winter-roosting blackbirds and starlings and piscivorous birds in commercial aquaculture.

Stickley, Allen R., Wildlife Biologist (Research)—Problem definition and control-methods development studies of winter-roosting blackbirds and starlings and piscivorous birds in commercial aquaculture; also histoplasmosis problems in regard to bird roosts.

Woronecki, Paul P., Wildlife Biologist (Research)—Development of methods for capturing nuisance birds, evaluation of nontarget wildlife hazards related to the use of avicides, and evaluation of various techniques for repelling birds.

International Programs

Brooks, Joe E., Wildlife Biologist (Research)—Vertebrate pest management related to agricultural crops and human health, particularly in tropical and subtropical countries.

Fiedler, Lynwood A., Wildlife Biologist (Research)—Rodent pest management in tropical agricultural crops.

Keith, James O., Wildlife Biologist (Research)—Environmental effects of large-scale pesticide applications, particularly on vertebrates.

LaVoie, G. Keith, Wildlife Biologist (Research)—Vertebrate pest management in field crops and stored grains.

McConnell, John E., Jr. Project Manager, Logistics Coordinator, Morocco.

Spillett, J. Juan, Wildlife Biologist—Rodent biology, behavior, and control in the Tropics.

Predators

Burns, Richard J., Wildlife Biologist (Research)—Application of behavioral patterns and principles to develop new or improved depredation control devices and tools.

Gruver, Kenneth S., Wildlife Biologist—Predator biology and control.

Jaeger, Michael M., Zoologist (Research)—Studies of bird-predator biology, behavior, and control.

Knowlton, Frederick F., Wildlife Biologist (Research)—Incorporation of ecologic, demographic, and behavioral information into depredation control programs to make them more effective, efficient, and socially acceptable.

Nass, Roger, Wildlife Biologist (Research)—Wildlife biology, with emphasis on predators.

Pan, Huo-Ping, Research Chemist—Development of safe predator-control agents and methodology by creative application of biochemistry.

Phillips, Robert L., Wildlife Biologist (Research)—Research to improve tools used in controlling coyote depredation.

Stoddart, L. Charles, Wildlife Biologist (Research)—Population dynamics, predator–prey interactions, and mathematical modeling of biological systems.

Windberg, Lamar, Wildlife Biologist (Research)—Predator population dynamics and identification of depredation control procedures that are selective for individuals causing problems.

Zemlicka, Doris E., Wildlife Biologist—Coyote behavior studies and development of more acceptable depredation control practices.

Chemistry/Registration of Pesticides

Bullard, Roger W., Research Chemist—Environmental chemistry and flavor chemistry research as related to animal damage control problems.

Garrison, Melvyn V., Research Physiologist—Bait formulation, toxicity testing, and animal nutrition.

Goldade, David A., Chemist—Technical and formulation assays and residue determinations for specific chemicals in a wide variety of sample matrices.

Goodall, Margaret J., Chemist—Scheduling, oversight, and qualitative and quantitative assessments of pesticides and other chemicals used in the Center's research.

Hurlbut, Daniel B., Chemist—Chemical research and development of analytical methods to support environmental fate studies for agricultural chemicals.

Johns, Brad E., Research Physiologist—Wildlife physiology as related to toxicants, marking agents, and reproductive inhibitors.

Kelly, Kevin L., Research Chemist—Investigation of applicability of supercritical fluid technology to analytical research.

Kimball, Bruce A., Research Chemist—Exploratory research in analytical chemistry relating to animal damage control.

Knittle, C. Edward, Wildlife Biologist (Research)—Telemetry and related behavioral activities of avian species.

Miller, Lowell A., Research Physiologist (Immunology)—Immunocontraception, vaccine delivery systems, and immunology laboratory science.

Mishalanie, Elizabeth A., Supervisory Research Chemist—Director of Research and Methods Development Project which aims to develop, evaluate, and validate new analytical chemistry methods for pesticides, control chemicals, and biological markers used by researchers at the Center.

Okuno, Wally, Research Chemist—Conduct of chemical research and development of analytical methods relating to animal damage control.

Primus, Thomas M., Research Chemist—Development of methods for the analysis of agricultural chemicals in baits, formulations, and environmental matrices.

Ramey, Craig A., Wildlife Biologist (Research)—Chemical registration; telemetry, and population biology of vertebrates.

Savarie, Peter, J., Pharmacologist (Toxicology)—Predacides and rodenticides.

Schafer, Edward W., Jr., Supervisory Research Chemist—Avian toxicology and chemical registrations.

Starr, Robert I., Research Chemist—Studies in soil chemistry, the environmental fate of pesticides, plant physiology, biochemistry, and pesticide methods development.

Sterner, Ray T., Research Psychologist—Vertebrate feeding behavior and aversion or bait shyness responses.

Thompson, R. Daniel, Research Physiologist—Animal physiology and control-methods development pertaining to avian pest species, wild rodents, and vampire bats; environmental physiology of dairy cattle.

Mammals

Campbell, Dan L., Wildlife Biologist (Research)—Silvicultural modifications; aversive conditioning, repellants, and barriers for forest and agricultural animals; toxicant evaluations.

Elias, Donald J., Wildlife Biologist (Research)—International vertebrate pests, primarily in Latin America; economic impact of vertebrate pests.

Hegdal, Paul L., Wildlife Biologist (Research)—Nontarget hazards of vertebrate pesticides and radio-telemetry applications.

Matschke, George H., Wildlife Biologist (Research)—Laboratory and field evaluations of rodenticides and chemosterilants.

Nolte, Dale L., Research Ecologist—Chemo-ecology, plant and animal interactions, and behavioral and habitat modification.

Shumake, Stephen A., Research Psychologist—Sensory characteristics, conditioning/learning effects, and natural behavior of vertebrates.

Tobin, Mark E., Wildlife Biologist—Wildlife ecology, especially as it relates to the impact and control of vertebrate agricultural pests.

Information Transfer

Connolly, Guy, Wildlife Biologist (Liaison)—All aspects of wildlife damage management, as well as coyote depredation control and control methods such as the livestock protection collar and M-44 sodium cyanide ejector.

Dwyer, Diana L., Supervisory Librarian (Biological Sciences)—Information and technology transfer of vertebrate pest control research and the development of information data bases.

Paulik, Laurie A., Librarian (Biological Sciences)—Development and maintenance of library reference, technical services, and information access capabilities to respond to user requests for online searches, reprints, reports, and other materials.

Smillie, Sella A., Records Manager (Archives)—Development of DWRC archives for the storage and protection of scientific studies and other research.

Support Services

Dale, Albert F., Supervisory Veterinary Medical Officer—Veterinary medicine and care of captive wild animals.

Engeman, Richard E., Statistician (Biology)—Sampling and experimental design development for animal damage studies.

Groninger, N. Paige, Computer Specialist—Data-base and systems design, computer programming, and microcomputer hardware and software setup.

Kolz, A. Lawrence, Supervisory Electronics Engineer—Development of electronic instrumentation for applications in wildlife control methods, population monitoring, and behavioral studies.

Krupa, Heather, Statistician—Experimental design development and review, data analysis, and statistical computing.

Mitchell, G. Clay, Quality Assurance Officer—The guarantor that DWRC complies with the current standards for Good Laboratory Practices as defined by EPA.

Publications—Fiscal Years 1991 and 1992

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Avery, M. L.; Decker, D. G. 1992. Repellency of cinnamic acid esters to captive red-winged blackbirds. Journal of Wildlife Management 56(4): 800–805.

Avery, M. L.; Decker, D. G. 1991. Repellency of fungicidal rice seed treatments to red-winged blackbirds. Journal of Wildlife Management 55(2): 327–334.

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Brugger, K. E. 1991. Anatomical adaptation of the gut to diet in red-winged blackbirds *(Agelaius phoeniceus).* The Auk 108: 562–567.

Brugger, K. E. 1992. Repellency of sucrose to captive robins. Journal of Wildlife Management 56(4): 794–799.

Brugger, K. E.; Nelms, C. O. 1991. Sucrose avoidance by American robins *(Turdus migratorius):* implications for control of bird damage in fruit crops. Crop Protection 10: 455–460.

Brugger, K. E.; Labisky, R. F.; **Daneke, D. E.** 1992. Blackbird roost dynamics at Millers Lake, Louisiana: implications for damage control in rice. Journal of Wildlife Management 56(2): 393–398.

Burns, R. J.; Connolly, G. E. 1992. Toxicity of Compound 1080 to magpies and the relationship of dose rates to residues recovered. In: Borrecco, J. E.; Marsh, R. E., eds. Proceedings of the 15th Vertebrate Pest Conference; 3–5 March 1992; Newport Beach, CA. Davis, CA: Vertebrate Pest Council: 403–408.

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Campbell, D. L. 1992. Forest wildlife damage management to improve forest health. Northwest Woodlands 8(4): 22–23.

Campbell, D. L.; Farley, J. P.; Hegdal, P. L.; Engeman, R. M.; Krupa, H. W. 1992. Field efficacy evaluation of diphacinone paraffin bait blocks and strychnine oat groats for control of forest pocket gophers (*Thomomys* spp.). In: Borrecco, J. E.; Marsh, R. E., eds., Proceedings of the 15th Vertebrate Pest Conference; 3–5 March 1992; Newport Beach, CA. Davis, CA: Vertebrate Pest Council: 299–301.

Campbell, D. L.; Farley, J. P.; Engeman, R. M. 1992. Field efficacy evaluation of pelleted strychnine baits for control of mountain beavers *(Aplodontia rufa)*. In: Borrecco, J. E.; Marsh, R. E., eds., Proceedings of the 15th Vertebrate Pest Conference; 3–5 March 1992; Newport Beach, CA. Davis, CA: Vertebrate Pest Council: 335–339.

Clark, L. 1991. Odor detection thresholds in tree swallows and cedar waxwings. The Auk 108: 177–180.

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Engeman, R. M.; Swanson, G. D. 1991. On analytical methods and inferences for 2 × 2 contingency table data from medical studies. Computers and Biomedical Research 24: 509–513.

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